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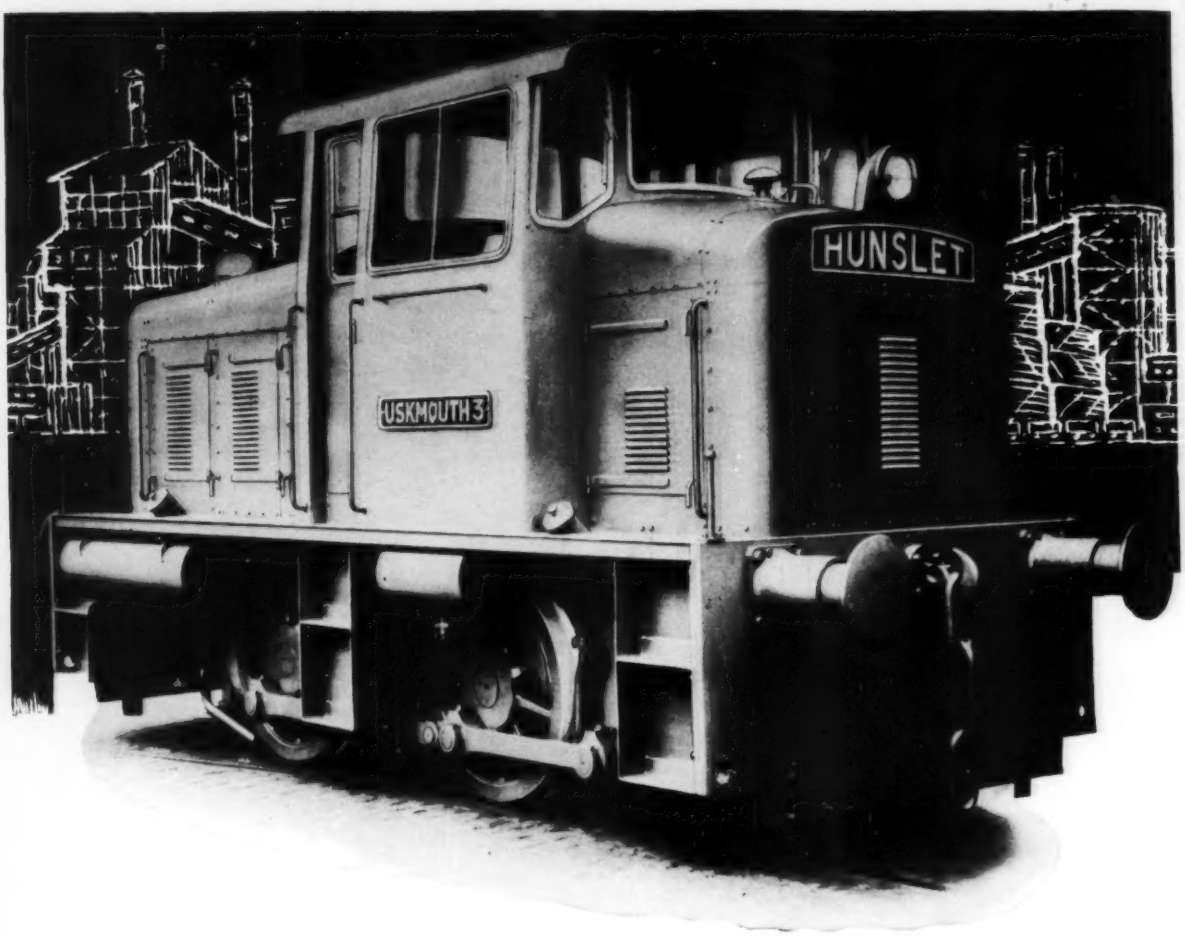

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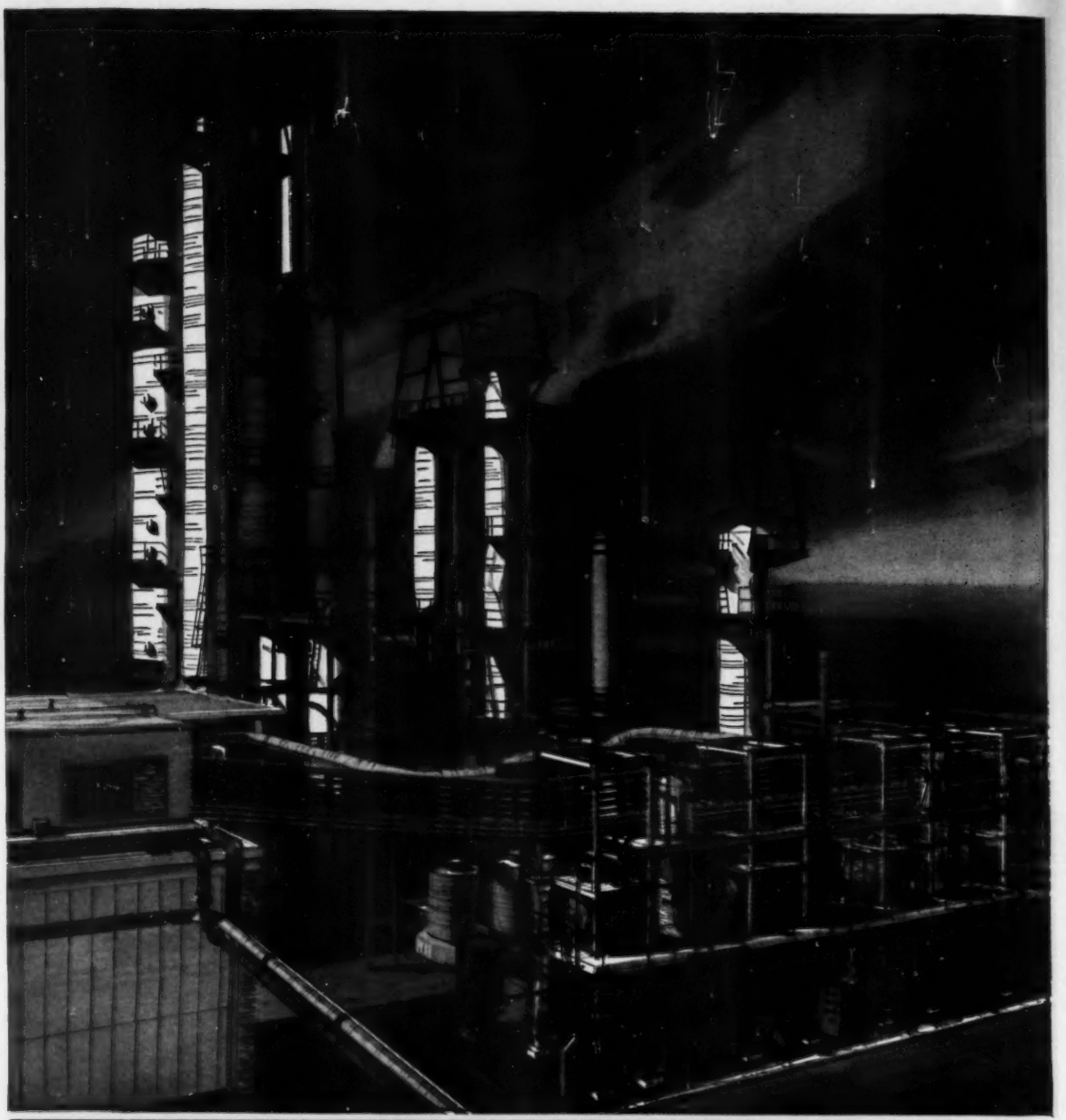

An artist's impression of the High Pressure
Oil Gasification Plant nearing completion at the
Isle of Grain Works of the South Eastern Gas Board

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Message from the President

It is my privilege, as President, to introduce this first issue of the monthly *Journal* of The Institution of Gas Engineers. I do so with the greatest pleasure and with full confidence that our members will welcome its publication.

Our new *Journal* should effect considerable savings in two important respects—time and money.

The Council has, for some considerable time, been aware of the disadvantages associated with the practice of publishing an annual volume of *Transactions* which could not be made available to members until after the Institution year that it covered. Our new Institution *Journal* will minimize this time lag.

The cost of printing the Institution's publications has been increasing progressively and quite substantially in recent years. With the support, which has readily been forthcoming, of those friends who are advertising in our *Journal*, we shall effect considerable economies in printing costs.

The *Journal* will contain all the reports and papers presented at the General Meetings of the Institution, as well as the discussions. It will also include reports from the Sections and affiliated Senior and Junior Associations with abstracts of papers presented at their meetings, and we shall publish, also, the general news items that have hitherto been included in our bi-monthly *Bulletin*.

Although much consideration has been given to the detailed presentation of all the items I have mentioned, it would be unrealistic to suppose that we cannot effect improvements in the light of experience which we gain, and, to this end, the Council will gladly receive and consider any suggestions that members may care to offer.

I take this opportunity to wish all members of The Institution of Gas Engineers and all non-member readers of our *Journal* good health and happiness in the New Year.

Hugh Chatham

President

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THE CHOICE OF SUBJECTS FOR RESEARCH AND DEVELOPMENT

By Sir HAROLD HARTLEY, G.C.V.O., F.R.S., Hon.M.I.Gas E.

COMMUNICATION NO. 578

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I SUMMARY

This paper is an attempt to outline the criteria and motives underlying the choice of projects for research and development in industrial laboratories. These are dealt with in a general survey under the headings of "First Aid", "The Improvement of Existing Practices and Products" and "The Invention and Development of New Techniques, New Materials and New Appliances". Each section is illustrated by a number of examples drawn from various industries, in the second section mainly from the gas and coal industries.

The final section, headed "The Choice of Projects for Research and Development in the Gas Industry", reviews some of the problems facing The Gas Council and the Area Gas Boards in the light of the recent Report of the (Wilson) Committee on Coal Derivatives and is directed particularly to an analysis of the potentialities of a high-pressure slagging gasifier.

II INTRODUCTION

The President's invitation to contribute a paper to the 26th Autumn Research Meeting gave me special pleasure as it seemed an opportunity to repay in some small measure the many acts of kindness I owe to the Institution and its members over the past 40 years. The choice of a subject was easy for me, with the recollection of a remark I made to Thomas Hardie, an outstanding gas engineer, while he was driving me back to Paddington after my first visit to Beckton, where I had seen a new research laboratory in the Products Works, but none in the Gas Works. "Don't you think," I said "that the centre of gravity of your research is in the wrong place?" It was not long, thanks to Sir David Milne Watson's prescience, before the Fulham Laboratory was built. When I showed the plans to the Works and Products Committee, wondering whether Thomas Goulden would think them extravagant, all he said was: "You ought to be ashamed

of yourself for not making them twice as large ", and within a short time the laboratory was doubled as Goulden's wise foresight had anticipated. It was a good omen for the future of that close working between the engineers and research and development on which so much depends.

It has been my good fortune for many years to have had the opportunity of following research and development in different industries both at home and abroad, and in this paper I have tried to sketch the different aspects which that research may assume, the factors that should determine the choice of objectives and the effort directed to each of them, and, most important of all, the watchful but sympathetic eye that must guide research and development policy. Of course, there is the fundamental difference between academic and industrial research so well expressed by Professor Jewkes' aphorism that " Science is directed towards understanding and technology is directed towards use ". While the economic aspects of research and development must always be the governing criterion of policy, I am frankly sceptical of schemes for the numerical appraisal of the relative merit of different projects. The ultimate decision must be a matter of judgment trained by previous experience and seen at its best in individuals, like Charles Kettering of General Motors, gifted with intuition. I remember Josiah Stamp saying to me when I went to Euston in 1930 : " Remember, when you were writing a paper for The Royal Society you were trying to be 100 per cent right, in the L.M.S. you are doing well if you are 60 per cent right ", and 60 per cent is a high target in research and development. Kettering was critical of educational systems that taught the danger of failure. Failure to him was an opportunity to find its cause. " You must learn how to fail intelligently. . . . I can take any group of young people and teach them to be inventors if I can get them to throw off the hazard of being afraid to fail ".

There are, as you know, different angles of approach to industrial research, which Kettering once described to me : " You can have a Monte Carlo when you put a lot of clever young men into a laboratory and hope for something to turn up. You can build a publicity laboratory in stainless steel, fill it with coloured bottles and apparatus and send for the Press. But then there is the real thing when you make up your mind what is needed and go for it ". And that, of course, is what he had done with the self-starter, lead ethyl, and the diesel-electric locomotive.

There is no hard and fast classification of research and development procedure. Research covers theoretical investigation and preliminary work in the laboratory ; development, the engineering design and construction which may find expression in pilot plants or in some cases be tested on a large scale with a great saving in time and cost of the preliminary work. In this paper, for convenience I shall deal with research and development projects under three sections : first aid when some emergency calls for immediate help from the research laboratory ; the improvement and development of existing processes, products or plants and the invention and development of new techniques, new materials and new appliances.

III FIRST AID

One of the duties of the staff of an industrial research laboratory is to be in close touch with operations, whatever form these may take, so that they can be thinking ahead for the operating engineers and ready to help in case of an emergency. A good example of the need for first aid was the sudden outbreak of gum in the middle 1930s due to the reaction between nitric oxide and the unsaturated hydrocarbons in the gas, which threatened to suspend the operation of all the gas meters in the London area. We mobilized all the research forces in the Company, and their continued efforts soon found ways of putting a stop to this threat. On the L.M.S. railway about the same time a mechanical system of safety equipment began to fail inexplicably on the wrong side, i.e., to give a false indication of safety. One of the functions of a research department is to have available a variety of investigational techniques, and on this occasion, as on others, a high-speed cinecamera quickly detected the occasional aberration of one component of the machine. We built a wind tunnel in order to analyse the air resistance to fast-moving trains of various designs and subsequently it was often in use to help in solving quite different problems. However, any idea of self-sufficiency is a serious defect in a research department, whose function should be to command the best advice and help anywhere in the World. The instability of the original design of the Viking aircraft under icing conditions, which only came to light when it was in service, was another emergency that research had to tackle quickly.

In addition to the advantages accruing from the solution of these first-aid problems, such incidents may be of value in two other ways. They may throw up possibilities that are worthy of further investigation, and they should breed an atmosphere of confidence and closer working between the engineer and research. I remember when we were investigating the possibilities of a new device, which in an altered form is now being used on British Railways, the chief engineer in charge of it asked me, as a personal favour, to entrust the experiments entirely to his own staff. A year later he came back to say they were in trouble and would the research department please help? I was once in Kettering's office in Detroit, when one of his assistants came rushing in, saying indignantly : " That d--d fool at X is ringing up again to say that his castings are failing ". " Don't you see ", said Kettering, " that you are the d--d fool for not taking advantage of your opportunity to show what research can do for him ".

First aid may interrupt a research programme—quick action is the essence of the contract—but it is a golden opportunity for the research department ; it must never be allowed to degenerate into a routine operation.

IV THE IMPROVEMENT OF EXISTING PRACTICES AND PRODUCTS

The urge to apply research and development to existing practice comes in many ways. The incentive of economy, the stress of competition, the lessons of operating experience, the need of better and more saleable products, and the satisfaction of improvement. In this competitive World, nobody can stand still, and capital investment without research is likely to lead to duplication of the methods of the past. The immense increase in the expenditure on industrial research and development which has risen in the United Kingdom from a mere pittance in 1900 to an estimated cost of over £400 mill. in 1958-59, is a measure of the importance it has now assumed, with the rapid growth of fundamental knowledge waiting to be applied in industry. So large a

fraction of our scientific manpower is now devoted to this end that the selection of research projects and the guidance of their progress has become a matter of national importance. How should one choose, and what should be the division of effort between the development of existing practices and the possibilities of entirely new departures in the future? For the former, it is usually possible to make some rough estimate of the monetary value of the exploitation of success, and this, and not the intrinsic scientific interest of the work, should govern the choice. When a research department was set up in the L.M.S. railway, we studied, on the one hand, a statistical analysis of all expenditure on materials, on construction, operations and maintenance to ensure that projects were chosen in which a possible improvement would lead to a significant financial gain. Of equal importance, though harder to evaluate, were projects leading to improved service to the passenger or consignee. This duality of choice is common to most industrial concerns and the balance between them is a matter of commercial judgment.

It is probably true that the cost of many materials and services have tended to fall in terms of real money, and in this research can claim a large share. One of the functions of research is to provide accurate and simple means of measurement by which efficiency can be judged. The constant striving after higher efficiency has been a major factor in improvement. The analysis of failures and their elimination has been of equal importance, leading to higher availability and to the economies that come from the larger units that are justified by an increase in reliability. Reliability and scale of operation go hand in hand. Greater reliability may come from research into improved materials or into improved design. The spectacular fall in the capital cost of conventional steam stations for the generation of electricity is due to the progressive increase in the size of the generators, and to the increase in the pressure and temperature of steam with the aid of improved materials and design. There were also the new techniques of reheat and the hydrogen-cooled generator with its savings in size and simplicity of design. This recalls Whitney's classic directive,[1] written in longhand to a young assistant, which started this development at Schenectady :— "Dear Chester," he wrote, "Could I create an interest for you in a series of fool stunts which have, I think, the promise in them of some useful outcome? I'd like to study experimentally (not on paper, because I expect the unexpected when we deal with such a complex subject ;) and this is it. I want to take a motor generator set and enclose it gas-tight, replace the air with hydrogen and run the thing. When this is done I want to see what the effect was (not before) . . . Don't worry about cost, leakage or danger. I've got that done already,—Whitney."

Operational research into the analysis of maintenance costs and the evaluation of systems of scheduled maintenance to avoid plant being out of action for long periods have also made a considerable contribution by avoiding the costly provision of stand-by plant. Some of the oil companies are now devising research techniques to examine the absolute need for maintenance, e.g., by measuring deposits on the extent of corrosion, so as to delay any shut-down as long as possible consistent with safety. Protection against corrosion has made immense strides in recent years, without which, for example, the steel pipelines that are playing such an important rôle in the transport of large blocks of energy would not have been possible.

Research into instrumentation and automatic control has also helped in the design of larger units and contributed to higher efficiencies and to a more constant quality of product, coupled with the economies of distant control. The instrumentation of critical areas of major equipment, such as superheater tubes and reheater tube metal temperatures, allows the operation of equipment at the true design limits of the components rather than at some artificially created limit that does not bear a real relation to the properties of the materials in question. It has also been a considerable factor in the trend towards the construction of continuous processes in place of batch processes, with the advantages they offer of lower capital costs, greater throughput and of continuous operation under optimum thermo-dynamic conditions. Research into physical methods of measuring and recording continuously the composition of raw materials and products, in place of the slower and laborious chemical methods of analysis, has been of special importance in this field.

In this section, I have merely sketched some of the trends of the development of existing practices to indicate certain considerations and criteria that might be applied in assigning priorities to possible research projects. Lower cost of the final product, whether it be in the form of services, appliances or materials, and its improvement in quality, form and durability to make it more saleable, are obviously the ultimate objective of research and development.

There are no better examples of the improvements that can be made in existing processes in the light of operating experience than the developments in the gas industry since the Gas Act, 1948, in the production, purification and utilization of gas. The steady improvement of the continuous vertical retort is the product of close collaboration between the gas industry and the contractors in research and development. Operational research into the optimum cross-section and taper of the retorts, the use of new techniques, better materials and improved insulation have resulted in increased throughput and higher yields, better quality of gas and higher thermal efficiency. The striking success of recent work on the gasification of petroleum products and of the importation of liquefied natural gas in reducing the cost of gas therms is referred to later in this paper.

The improvements in gas purification, although perhaps less spectacular, have been the result of continuous research both in the laboratory and in the plant, and they are a particularly good example of the advantages of a close connexion between research and development and engineering. The raw gas from the retorts is a complex mixture of products, some of which may cause serious trouble if they are not eliminated, and others are of value only if they can be recovered at an economic cost. The purity of the gas is essential for its domestic use. The quantities to be dealt with are very large, and a high degree of reliability must be maintained. A major improvement has resulted from the rapid rotation of oxide boxes with automatically controlled valves, and from the design of tray purifiers with mechanical discharge. There are many other improvements ; this, however, is not the occasion to quote details, but to emphasize that the cost efficiency of modern purification practice reflects the efforts of a succession of able chemical and gas engineers in the industry, who have devoted their lives to these problems.

Of equal value over the past 40 years has been the development of the appliances in which gas is utilized. In this field, the work at Watson House has had a profound effect on appliance design and development, and I wish to pay a tribute to the three men who have been mainly responsible—Masterman, Dieterichs and Andrews. Since 1930, over 160 technical papers have been published from Watson House dealing with the basic principles of gas utilization, and these have had an overall influence on all types of appliance design, on test standards and on installation practice. There has been close co-operation with appliance manufacturers throughout, and many of the Watson House contributions have been further developed in the manufacturers' laboratories. The investigations have covered the whole range of the applications of gas heating in the home, in industry and in catering appliances. By increasing efficiencies, they have done much to improve the competitive position of gas.

There is one outstanding development in the coal industry, which seems to me specially relevant to this occasion as I believe that the futures of gas and coal are so intimately linked together. In recent years, there has been a complete change in the methods of mining coal. The pick and shovel gave way, first, to the coal cutter, and more recently to power loading machines that cut and load the coal on to conveyors as they traverse the face. This change has necessitated a revolution in the types and systems of roof support.

In pick-and-shovel days, wooden props were used, followed by rigid steel supports introduced on to machine-cut faces. It was soon clear that a new prop was needed, adjustable in length, designed to yield at a predetermined load and capable of rapid and safe release so that it could be withdrawn and used again. In 1946, a firm with experience in making hydraulic undercarriages for aircraft designed a hydraulic pitprop, 820,000 of which were in use at the end of 1959, representing 25 per cent of the supports in use in the United Kingdom. However, it was then found that the advance and setting of the individual props was a limiting factor in the continuous advance of fast-moving power loading machines, so the National Coal Board co-operated with a number of firms making hydraulic pitprops to develop power-operated support systems. This development has produced the Gullick Seaman power-operated chock system and the Dowty roof-master system, and, by the end of 1959, 75 faces were supported by power-operated support, with the prospect that these may soon be remotely controlled.

The advantage of these developments in the winning of coal is seen in the latest figures for the number of man-shifts required to produce 1,000 tons of coal at the coal face. For non-mechanized faces, this is 254 ; for mechanized faces, 150. In the East Midland Division this is 120, the best figure for an area being 92.

In addition, great progress has been made in supporting the roofs of roadways by " strata bolting ". This consists of steel rods inserted in holes drilled through the bedding planes of the strata, with an anchoring device at the inner end and a bearing plate and nut at the outer. Tightening the nut has the effect of tensioning the bolt, and the layers of rock are drawn together, thus adding to their strength so that the beam formed by the nuts is similar to the structure of a reinforced concrete beam.

These great changes in the coal industry should have important repercussions in the gas industry. Mechanization reduces the price of some types of coal more than others, and, in particular, has reduced the cost of the kind of coal acceptable to electricity generating stations. The siting on the coal fields of complete-gasification plants designed to use the cheaper types of coal produced by fully mechanized mines should give the gas industry the advantage of these developments.

V THE INVENTION AND DEVELOPMENT OF NEW TECHNIQUES, NEW MATERIALS AND NEW APPLIANCES

Professor Jewkes and his collaborators Sawers and Stillerman in their invaluable book *The Sources of Invention*[2] have given case histories of 50 of the more important inventions of this century and have analysed the contributions of the individual inventor and of corporation research, the great innovation of the period. It is an unflattering comment on human nature that wars and the threat of war should have been so largely responsible for the financial support of the great upsurge of scientific effort that has been the outstanding characteristic of the 20th Century. While the individual inventor, the man with the creative imagination to foresee new means of meeting human needs, or, indeed, of inducing new needs by his creations, still plays an important rôle, unquestionably the rapid advance of scientific knowledge has prompted many of the most significant inventions in recent years. In either case, the invention has normally to pass through the successive stages of research and development, and the ultimate value of a new product or device depends both on success in producing it at an economical cost and on the public demand that it meets or creates.

One of the most successful inventions not included in Professor Jewkes' list is the self-starter of motor cars, due to Charles Kettering in his early days at Dayton, Ohio, since it met such an obvious need, and few inventions can have obviated so much human blasphemy. When Delco (Dayton Engineering Laboratories Co.), Kettering's first individual venture, was given the order for 12,000 self-starters for the 1912-model Cadillac, Kettering asked the Storage Battery Company for a quotation for 10,000 batteries. Their salesman greeted him : " I don't want to sell you any batteries. I just want to look at a fellow who thinks he wants to buy that many batteries."[3]

How to save the consumers' pocket was always in Kettering's mind, and lead ethyl, due to his initiative and Midgley's " scientific fox hunt ", is estimated to be saving motor users in America 5 billion dollars a year. The economical design of the diesel-electric locomotive, again initiated by Kettering, speedily rendered coal-fired locomotives obsolete for the long hauls under American conditions, since, as one of the greatest protagonists of the older type said to me : " It can do all that a steam locomotive can do, and do it better."

Those are three examples of the creations of an inventor, supported, it is true, in later years by the research department of a powerful corporation.

The zip fastener was another brilliant anticipation of a widespread need and an object lesson in the pertinacity of inventors.[4] The first patent for a slide fastener was taken out in 1891 by Judson, a mechanical engineer and professional inventor with 30 different patents to his credit. The idea went through a series of changes, all of which were difficult to manufacture until, in 1905, Sundback, a Swedish engineer, was brought in to help. Meanwhile, many other inventors had joined in the hunt and filed patents. But finally, in 1913, Sundback after many failures (he took out 78 patents in this field) filed the patent that is essentially the modern slide fastener, and in 1916 the patent for a successful machine to make it. The 1914-18 war gave the Hookless Fastener Company its first boost. A chance meeting in the bar of an Atlantic liner led to the sale of the rights outside America to Kynochs, but it was not until 1925 that the zipper began to come into general use.

The printed circuit[5] now so universally used in electronics and in other ways was invented by Dr. Paul Eisler in Britain in 1936, but no manufacturer would look at it. The breakthrough came in 1947 with the publication of the details of the American proximity fuse in which this technique was employed. There are now many ways in which this invention is utilized, either by printing the circuit with a protective ink on copper foil mounted on plastic and etching off the remainder, or by the use of a stencil and deposition of a conducting circuit. The printed circuit and the transistor have been the key to miniaturization.

The modern tubular scaffolding that has done so much to facilitate rapid building construction is another 20th Century

invention. Patents of clamps or adjustable clips to replace scaffold cords in the early 1900s made slow progress and met with opposition from the scaffolders. In 1914, a patent was granted to Daniel Palmer-Jones for the use of tubular steel standards with timber horizontals, but the revolutionary change came in 1918 with his patent for the design of the first metal coupler to join steel tubes together to form tubular scaffolding.

Turning now from the brain-wave of the individual inventor to the inventions that have originated with scientific research, we can distinguish between some unexpected application, like the control of machine tools by diffraction gratings, made possible by inexpensive methods of production originally suggested by Sir Thomas Merton[6] (whose new method of ruling gratings was itself a brilliant invention), and inventions like nylon, which came from Carothers' deliberate attack on new methods of making polymers.

It is usually only large corporations or government-sponsored laboratories that can afford the latter line of approach, Kettering's Monte Carlo, and even then success depends on the genius of the individual investigator rather than the scale of the attack. When Kettering was once asked to add 20 men to a team in order to expedite a particular research, he said : " You don't need 20 bodies, you need one brain ". The outstanding success of the Bell Telephone Laboratories in their investigations into the solid state, which have led to the invention of the transistor and of the maser (microwave amplification by stimulated emission of radiation), was due to the brilliance of the members of their staff, four of whom have been Nobel Laureates — Davisson, Shockley, Bardeen and Brattain. The maser opens the way to transmission programmes that were formerly beyond reach : the transmission of television programmes and telephone conversations *via* signals reflected from satellites. In the General Electric Company's Laboratory at Schenectady, Whitney, with the hydrogen-cooled generator, Coolidge, with his X-ray tube, and Langmuir with his gas-filled filament lamp, have all been outstanding investigators, and the by-products of their scientific work have paid good dividends. Likewise, in Du Pont's laboratory at Wilmington, Carothers was given a free hand by Stine and Bolton to investigate the phenomena of polymerization, and among its products was the mixed polymer of adipic acid and hexamethylene diamine, which was found to have such a high commercial value as a man-made fibre in nylon. The discovery of terylene, polyethylene terephthallate, by Whinfield and Dixon in the laboratory of the Calico Printers' Association was partly inspired by Carothers' work and after a costly period of development yielded another synthetic fibre, competitive with nylon.

Another example of the successful outcome of fundamental work in an industrial laboratory was the accidental discovery of polythene (polyethylene) during an investigation into the effects of high pressure on chemical reactions in the laboratory of Imperial Chemical Industries : a happy example of serendipity. The commercial development of perspex (polymerized methyl methacrylate) was made possible by the discovery of an economical method of synthesis of the starting material by Crawford in the Imperial Chemical Industries Laboratories. Systematic search made possible by the resources of large corporations was responsible for the discovery of D.D.T., of streptomycin and other antibiotics and of giberellic acid.

These are all examples of the successful outcome of fundamental work in industrial laboratories in fields where there was some prospect of a useful product. There are other instances of scientific work leading to entirely unexpected practical results, and one of the duties of a research department is to keep a close watch on the literature so as to exploit any discovery likely to be of value in its particular field. The development of atomic energy, from the investigation of the disintegration of uranium by Hahn and Meitner, is the most spectacular of all. Fleming's valve, and his namesake's penicillin, and the silicones based on Kipping's work on organo-silicon compounds all come within this category, but their ultimate practical success involved a long period of development in other hands. Indeed, it has rarely happened that an inventor has carried through his project unaided to the commercial stage, though this is not true of two of the most far-reaching inventions, Parsons' steam turbine and Whittle's jet engine.

Of course, I have oversimplified the distinction between research and invention, as the two constantly react on one another as they did in the invention of the fluidized-bed catalytic cracker by Esso Research and Engineering Company (formerly Standard Oil Development Company), which is of special interest as it has had such a widespread effect on chemical engineering. The fixed-bed Houdry process involved regeneration by burning off the carbon deposited on the catalyst during the cracking operation. This suggested the possibility of using a powdered catalyst in suspension, which could be carried over into a separate chamber for regeneration. After some preliminary work with a dilute suspension, experiments by Dr. W. K. Lewis at M.I.T. (consultant to Esso Research) showed that, under suitable conditions, the particles of catalyst settled into a fairly dense layer that was perfectly mobile and acted as a fluid. This suggested the idea of using a dense catalyst fluid bed in a much smaller reaction vessel ; coupled with this came the idea, originated by several Esso Research employees (E. V. Murphree, D. L. Campbell, H. Z. Martin and C. W. Tyson), of building up a dense column of catalyst and keeping it aerated so that it could be used as a pressure standpipe to force the catalyst from a zone of lower pressure into a zone of higher pressure. These two ideas were embodied in August, 1940, in the pilot plant at Baton Rouge in order to circulate the catalyst continuously between the reaction vessel and the regeneration vessel, in which the carbon was burnt off in a stream of air and oxygen. The whole development went remarkably smoothly and was completed within a year.

VI HOW SHOULD ONE CHOOSE?

This brief sketch of the chain of events leading up to successful industrial developments of various kinds may throw some little light on the criteria that may guide the choice of projects for research and development. As Jewkes points out, even in these days of big corporations the individual inventor is still a major factor, and the corporations have still to rely heavily on other sources of original thinking. However attractive the adventure of a major break through may seem, in spite of the heavy liabilities it may involve, the bulk of the work of most industrial laboratories will be concerned with first aid and with the improvement and development of existing processes in the light of the growing volume of scientific knowledge. The choice of the latter projects, the former choose themselves, must rest on cost analysis, on market research, on judgment of their scientific and engineering possibilities, and on the effort available in the research staff. Laboratory research is comparatively cheap, development is much more costly, and this liability in case of success must not be forgotten at the outset. In many cases, much

can be done to minimize development costs by theoretical studies, followed by laboratory work to determine the basic data involved, and by design studies to evaluate the possibilities. In these ways, it may be possible to save time and money by omitting the stage of pilot-plant development and go direct to large-scale operations. This is where judgment and experience come in.

There is the eternal dilemma for a business as to how much it can afford to spend on research and what advantage it is gaining. The system of post-mortem enquiries as to the causes of success or failure of each project supplies a useful record of experience, which is often lost if not recorded in this way. Every research programme needs adjustment from time to time in accordance with its progress and other circumstances. The direction and administration of research is a very delicate matter, it needs an intimate day-to-day contact with the individuals concerned, it must not be frustrating or destroy confidence, remembering that all research is to some extent a gamble. The most successful system I have seen involved detaching a small group of able people from all responsibility for specific projects so that they could follow the progress of the different projects and keep in close touch with both the makers and the users of the products of the laboratory. The group was thus in a position to adjust the research programme to meet changing circumstances. It was on its advice that projects were strengthened if they showed promise and were needed, or slowed down, or stopped. It obviously required delicate handling, but it worked well and prevented projects being continued long after they were likely to pay any dividend. I have found that most scientists respond to the stress of urgency. It was certainly so in the laboratories of the Industrial Group of the Atomic Energy Authority at Risley when they were working to very tight time schedules in order to supply Sir Christopher Hinton with the fullest possible data at different stages of the design and construction of the Calder Hall reactors.

VII THE CHOICE OF PROJECTS FOR RESEARCH AND DEVELOPMENT IN THE GAS INDUSTRY

I come now to what you may regard as the touchstone of this paper, the application of the criteria I have outlined to the choice of projects for research and development in your own field. The gas industry is at the beginning of a transitional period and it needs to improve its competitive position as the following facts show. Between 1955 and 1959, when consumption of electricity continued its steady rise of 6 per cent annually, the consumption of oil rose by 12 per cent a year, while gas consumption showed a fall of 1 per cent annually and coal of 3 per cent. Clearly, gas and coal are losing ground to electricity and oil, particularly in the heating field, and the competitive power of gas in the future will depend mainly on the ability of the industry to sell it at a lower price. Let me remind you of the present prices of a therm of energy in different forms. At the average pithead price of coal, 1 therm costs 3½*d.*; at £10 a ton, 8½*d.* With fuel oil at £10 a ton, it costs 6*d.*; with paraffin at £20 a ton, it costs 11*d.*, whereas with gas at the average price it costs 1*s.* 9*d.*, and at the average price to industry 1*s.* 3½*d.*

Recognizing the urgent need for a new approach, much of the research of The Gas Council and the Area Boards in recent years has been directed to new methods for the manufacture of gas. The practical outcome of this work is already seen in the industry in the increasing use of a variety of petroleum products to provide both cheap peak-load gas and base-load gas by reforming hydrocarbon gases with steam and a catalyst or by incomplete oxidation[7], and also to provide new means of enrichment. Of the latter, the importation of liquefied natural gas by the North Thames Gas Board[8] on behalf of The Gas Council promises to be of outstanding importance. In addition to his work on the gasification of oil at Solihull, Dr. Dent[9] has investigated the production of rich therms by the hydrogenation of coal and has done preliminary work on a slagging gasifier. At the same time, much consideration has been given by Area Boards to the possibilities of building Lurgi plants for the complete gasification of British coal, and two Area Boards are now starting to build plants in or near the coalfields in Scotland[10] and the West Midlands to supply gas for use in their own areas. When the first stage of the West Midlands plant is completed, it will gasify 250,000 tons of coal/annum.

Meanwhile, Dr. J. Burns, G.M., in his Presidential Address to the Institution in 1959, pointed the way to a major development by describing the possibilities of a high-pressure national gas grid to carry gas, made under pressure by large complete-gasification plants on the coalfields, to the major centres of consumption.

VIII THE REPORT OF THE WILSON COMMITTEE

The Report of the Wilson Committee[11] gives the following estimate of the cost of 1 therm of gas made in a larger Lurgi plant in the Midlands gasifying annually 1 mill. tons of low-grade high-ash coal at an average price of 2·93*d.*/therm (or £2 12*s.* 6*d.* a ton), assuming that the purified lean gas from from the Lurgi gasifier, costing 9·1*d.*/therm, would be enriched by butane costing 7½*d.*/therm, and that the load factor is 86·5 per cent :—

Cost of Town Gas per Therm

	d.
Coal	3·68
Butane*	2·75
Operating Costs	1·64
Capital Charges	2·02
	10·09
Credit from By-products	1·50
Net cost per Therm *ex*-works ..	8·59

*Due to the composition of the shifted Lurgi gas, 37 per cent of the therms in the final town gas must be provided by enrichment.

No allowance is made in the above Lurgi costs for the recent improvements planned in the Ruhrgas plant at Dorsten including economies in steam and a more economical way of carrying out the shift reaction giving an improved yield of by-products. These together might reduce the cost per therm by 1*d.* On the other hand, the Wilson Committee points out that its estimate is based on capital charges assessed at 8 per cent/annum, whereas with a charge of 12 per cent—"a figure which it is thought may be of more general application"—the cost of a therm would be increased by 1*d.* So these two factors might offset one another.

It is difficult to make a valid comparison between the above estimated cost of gas made under optimum conditions and

the cost of base-load gas made in conventional plants, owing to differences in load factor and in the cost of transport of coal, and the varying profitability of the coke market. However the investment policy of the Scottish and the West Midlands Area Boards in building Lurgi plants is significant. If we allow 0·4*d.* for the cost of transmission to London of gas made under pressure in the Midlands, the cost of 1 therm should be 9*d.* ex works, which would probably compare favourably with the present cost of making base-load gas in conventional plants in London.

One of the most significant aspects of the above figures seems to me to be the lower cost of rich therms from butane (7½*d.*) compared with the cost of a therm of the purified lean gas from coal (9·1*d.*). In this connexion, page 17 of the Report quotes the view of The Gas Council, that the future cost of producing town gas, including capital charges, should not exceed 10*d.* and should be preferably substantially less. It would be interesting to know to what extent The Gas Council in giving it had in mind the gasification of oil and the use of partly reformed hydrocarbon gases, towards which so much of the recent development in the industry has been directed, in accordance with the obligations of the Area Boards under the Gas Act, 1948, " to develop and maintain the . . . economical system of gas supply for their Area. . . . "

The Wilson Report points out an important limiting factor in the operation of a conventional Lurgi plant. The temperature of the fuel bed must be kept below the fusion-point of the ash to avoid slagging or clinkering. This involves the injection of excess steam in the oxygen/steam blast, less than half of which is decomposed in the fuel bed, so that there is a considerable effluent that complicates the process of purification and creates a disposal problem. The improved practice at Dorsten reduces this disadvantage of the process, especially if coals with high-melting-point ash are used, but this again limits the availability of suitable coal. The selectivity of the Lurgi plant in respect of the swelling number might also prove to be a limiting factor.

The Report then reviews the work that has been already done on the development of a slagging high-pressure gasifier[12 13], which is not subject to these limits and should have a higher throughput and a higher thermal efficiency, and comes to the conclusion that this shows promise of considerable advantages and that its development should be pursued. In this paper, I have stressed the part played by individuals in the invention and development of new processes, and I wish here to acknowledge how much we owe to the persistent advocacy of the slagging gasifier since 1953 by Mr. Campbell Secord, and to his fruitful ideas. It was first suggested by him, when he was adviser to the Ministry of Fuel and Power, to make cheaper synthesis gas for the Fischer-Tropsch process using compressed air, but as the result of a design study its suitability for making town gas using tonnage oxygen emerged.

In view of the paucity of experimental data, the Wilson Report quotes no estimates of the economic gain promised by the successful development of a slagging gasifier, but in the conclusions on page 26 the Report says : " These advantages should make possible improvements in the technique of gasifying coal, which in turn would lead to a significant reduction in the cost of gasifying coal." In the chapter dealing with the economic possibilities of making oil from coal in the United Kingdom, the optimum cost of producing synthesis gas from coal, " even assuming much more efficient processes than are available at present ", is estimated at about 7½*d.*/therm. This is in line with the estimates of the savings achieved by the full development of a slagging gasifier that have been made by comparing the results of experimental work with this type with the performance of existing Lurgi plants. The basis of these estimates can be set out quite simply as follows :—

If we compare the gasification of the same coal by Lurgi and slagging gasifiers, the higher temperature of the combustion zone of the latter (e.g., 1650°C compared with 950°C of the Lurgi) involves the consumption of more oxygen per ton of coal, but gives an advantage in the larger content of carbon monoxide and hydrogen and in the smaller content of carbon dioxide in the gas as shown in the table on page 80. Hence, after the shift conversion and removal of the bulk of the carbon dioxide, the slagging gasifier gives a higher yield of therms per ton of coal, and the consumption of oxygen per therm is about the same for both. Due to the smaller amount of steam required by the slagging gasifier, its thermal efficiency is higher and, with the advantage of the smaller content of steam and of carbon dioxide, the output of therms of gas from a slagging gasifier may be 75 per cent higher than that of a Lurgi plant with the same gas velocity. Also, with slagging conditions it may be possible to build units with a larger diameter. Due to the larger gas-making capacity of a slagging gasifier and the smaller boiler capacity needed, the capital cost will be reduced.

Taking all these possible advantages together, they should reduce the cost of the lean purified gas by at least 1*d.*/therm below Lurgi costs and thus provide a lean gas from coal that is cheaper than gas made from oil by reforming. Enrichment with cheap therms by liquefied natural gas or liquefied petroleum gas should improve the competitive position of gas in the future.

The additional possibility, envisaged in the Wilson Report, of delivering the lean gas by pipeline direct to industrial centres is dealt with later in this paper.

IX THE DEVELOPMENT OF A SLAGGING PRESSURE GASIFIER

The various possibilities of savings outlined above indicate some of the objectives at which the development must be aimed. None of the problems presented by this development, such as the high rate of fuel feed to a pressurized bed and the design of hearth to permit the flow and removal of the slag are insuperable ; the objective is to find solutions of them that can be embodied in an economic commercial unit. This is obviously an opportunity for an attack from different angles as it is unlikely that any one approach will find the complete answer.

An important aspect of the development programme will be to determine the optimum working pressure of the gasifier. Experience with the Lurgi type is limited to about 25 atmospheres. Increase of pressure increases the throughput and the yield of methane and is said to favour the formation of less complex compounds in the liquid products.[14] On the other hand, it might cause difficulties in the bed by increasing the plasticity of the coal. We need to know the effect of much higher pressures in order to evaluate the most economical working conditions.

The control of the conditions at the top of the bed will determine the yield of by-products, which may be an important factor in the economy of the process if their recovery is economic. This is intimately linked with the methods of purification of the gas, in which there is much scope for further research under the pressure conditions of the operation slagging gasifier.

In planning large-scale development, the slagging gasifier would have the great advantage that it could use a wider variety of coals and would not be limited by ash fusibility. It would, therefore, be much easier to find suitable sites for the plants on the coalfields. As no single pit would produce the amounts of coal required by a large installation, the gasifiers could be distributed at suitable pits with a large oxygen plant serving them all.

It is generally admitted that the future of coal will depend increasingly on its adaptation to more flexible utilization, and gasification is by far the most promising route. So the success of this development is of vital importance to coal as the gas industry has the alternative of relying more and more on oil products and imported natural gas. There is perhaps one caution to be borne in mind. At the moment, everybody is looking for means of exploiting the use of the cheaper types of coal. How far does their price depend on other users being prepared to pay more for the other types such as large coal and coking coal? Is the National Coal Board prepared to make long-term contracts with large consumers, giving them the advantage of a price based on the cost of winning the cheaper types of coal which they consume without subsidizing the cost of production of the more costly varieties?

X THE PRODUCTION OF RICH THERMS

As both the Lurgi and slagging gasifiers operating at 25 atmospheres pressure make a lean gas of calorific value 400 B.t.u./cu. ft. or less, enrichment to the extent of one-third or more of the therms is necessary. The Wilson Report points out that at present there is no economical method for producing these rich therms from coal, but they can be provided in a variety of ways from petroleum products, liquid natural gas (L.N.G.) or liquid petroleum gases (L.P.G.). Further research and development is called for to find the most economical means of providing these rich therms in future both from coal and oil. A large expansion of Lurgi or slagging gasifiers would entail a heavy demand for rich therms, so that alternative methods are needed to avoid excessive demand for a particular petroleum product, which might effect its availability and price.

The importation of L.N.G., which is now under large-scale development by The Gas Council, may prove to be the ultimate solution in view of the vast quantities of natural gas that are available. However, if it proves economical to operate gasifiers at a higher pressure, the resultant gas should have a higher calorific value, thus reducing the amount of enrichment.

XI TRANSMISSION AND STORAGE

Much progress has been made in recent years in modern techniques for the construction, operation and maintenance of steel pipelines carrying oil and pressurized gas, with the advantages of automatic control of booster stations, so probably all the necessary information is available to evaluate the most economical combination of pressure and diameter of pipelines for long-distance transmission of gas in the United Kingdom under different circumstances. The choice of the optimum conditions may effect large savings, so it calls for detailed investigation.

With the daily and seasonal load peaks and the economy of a high load factor for large production units, storage is an important factor. In the future, the capacity of high-pressure long-distance mains would act, like the Ruhr grid, as a gasholder and, by increasing the pressure at night and at weekends, would help to carry the daily variations. The only economical large-scale method of dealing with seasonal variations is underground storage in appropriate geological formations. Recent investigations have shown the possibility of using disused salt mines for this purpose, but this is only a local solution.[15] The Gas Council has undertaken an extensive investigation of possible underground storage sites, which has already yielded promising results. The handicap of the absence of natural gas fields in the United Kingdom is felt here again, as the worked-out fields make ideal storage. In the United States, the possibilities of storing liquefied natural gas underground are also being investigated.

XII THE INDUSTRIAL GAS OF THE FUTURE

The Wilson Report describes the possibilities of an industrial gas grid distributing lean gas under pressure, after a minimum of purification, to industrial centres, if it can be produced at a sufficiently low cost, the same gas grid being used to supply gas to local centres of the Gas Boards for final purification and enrichment to town gas standards.

The Report gives the following table of the volumetric composition of the gas made by the two processes :—

	Standard Lurgi Gasifier	*Slagging Gasifier*
CO_2	29·0	4·7
H_2S	0·8	0·7
C_mH_2 gases	0·3	0·2
H_2	41·0	25·6
CO	18·7	58·8
CH_4	9·4	9·0
N_2	0·8	1·0
Calorific Value (gross) (B.t.u./s.cu.ft.)	290	361
Calorific Value (net) (B.t.u./s.cu.ft.)	268	347

The relatively low content of both carbon dioxide and hydrogen in the gas from the slagging gasifier makes it particularly suitable for direct use in industry, due to the advantage of its higher net calorific value.

The minimum of purification necessary before transmitting gas in steel mains is the removal of dust, tar, naphthalene, ammonia and hydrogen sulphide, at a cost of roughly 1*d.*/therm. This would leave the organic sulphur in the gas, which might prejudice its use for certain industrial purposes such as metal annealing. It would, however, avoid the cost of the shift reaction and the subsequent removal of carbon dioxide and the loss of net thermal value due to the conversion of carbon monoxide to hydrogen.

A number of problems arise from this project of an industrial gas grid, which will need detailed examination. The argument for providing industrial gas at the cheapest possible rate is a strong one as gas is an ideal industrial heating agent and at a more competitive price would command a much larger market with a good seasonal load factor. Even if the national gas grid of the future carries town gas purified and enriched on the coalfields, there are likely to be dense areas of industrial activity to which an industrial pipe-line would be justified. The element of risk in the carriage of gas containing a large percentage of carbon monoxide in a high-pressure steel pipeline would need consideration.

In addition to industrial heating, there are many possibilities for the use of industrial gas in the future, which will be favoured by a cheaper price. Progress in the design of gas turbines to operate at higher temperatures and efficiencies will make them increasingly attractive with recovery of the waste heat to raise steam. The availability of cheaper gas might have a decisive effect on boiler design by making possible pressurized combustion chambers with a large saving in the size of the unit, as was demonstrated in the Mercier equipression-boiler.

Mr. Wynn, in his Thornton Lecture to the Association of Mining, Electrical and Mechanical Engineers, showed that the cost of transmitting energy in the form of gas made under pressure in high-pressure pipelines for a distance of 100 miles is only a fraction of the cost of transmitting the same amount of energy by high-voltage cable, and so it may well be that the Central Electricity Generating Board might find it economical to use gas as a fuel near load centres rather than siting their generating stations near the coalfields. There is also an increasing interest in the fuel cell, and its future will depend largely on the availability of cheap gas.

In an entirely different field, the steel industry is approaching a stage of transition. The increasing use of oxygen in steel making seems likely to be followed by important developments in blast furnace operations with the injection of oxygen and fuel and possibly the use of higher pressures. Thus, the evolution of the slagging gasifier might follow somewhat similar lines to the blast furnaces.

The gaseous reduction of iron ore by hydrogen and carbon monoxide is also under large-scale test at the moment. Reducing gases may play a larger part in the future, thus providing an opportunity for the slagging gasifier in countries with reserves of coal but no natural gas.

All these possibilities should be borne in mind in a critical analysis of the problems of an industrial gas grid, which should be made at the same time as the other development work as the two will react on one another.

XIII CONCLUSION

In a recent paper to the Fuel Luncheon Club, I said that our research and development programme in the field of energy seemed to me to be badly out of balance as the effort devoted to the better utilization of coal is so small compared with the large sums of money and the considerable fraction of our scientific effort that are being devoted to the nuclear field including thermonuclear fusion. The recommendations of the Wilson Committee do not relieve my mind on this subject as the scale of effort they recommend for the development of improved methods of gasification seems too small for the magnitude of the issue at stake : particularly with the various ancillary problems that I have indicated above. It is not only the interests of the gas industry that are concerned as the future of coal depends so much on its conversion to a more flexible and convenient form of energy. This seems to me to raise once again the crucial question of a national fuel policy, its bearing on our balance of payments, and the relations of the three energy industries to one another. For the present it can be argued that, in the interests of our competitive position in the world markets, industries must be allowed to use the cheapest forms of energy available at the moment. However, future policy must depend on the results of research and development, and, with the importance of the national issues at stake in the future of coal, the priorities and scale of expenditure on research are surely a matter of governmental concern and should not be dependent on the resources of a particular industry. In addition to its effect on the future energy economy of the United Kingdom, success in developing improved methods of gasifying coal could be a most valuable addition to our engineering exports on which the financial stability of the country is increasingly dependent.

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PRESENTATION, DISCUSSION AND REPLY

Presentation

Sir HAROLD HARTLEY presented his Paper as follows:—

May I first thank you for your kind invitation to me to contribute to this Autumn Meeting of the Institution, because it is a privilege that I greatly appreciate.

My paper is in two parts. The first is mainly a personal sketch of my experience in industrial research over the past 40 years, and I dare say that it will not raise any controversial points. I have illustrated it by some of the important developments that have taken place in both the gas and coal industries in recent years, and I shall add one wisecrack: Frank Jewett, President of the Bell Telephone Laboratories, once asked Professor Urey, the discoverer of heavy water, what was the difference between pure science and industrial research. "About 20 years", was the answer. That was 30 years ago, and I do not think it is true today, because you see how rapidly things are developing in the development of the transistor and mesa. That progress of knowledge is one of the things one has to bear very carefully in mind, in any research programme.

The second part of the paper deals with some research problems of the gas industry, and the fortunate appearance of the Wilson Report* while I was writing it gave me the opportunity to examine those of the conclusions and recommendations of the Wilson Report that relate specifically to the gas industry. You may have noticed that practically all the data in my paper are taken from the Wilson Report, which no doubt were chewed over very carefully by experts before they found their way into print.

The purpose of the second part of my paper was to provoke discussion on some of the important issues it raises—issues which, I suggest, are crucial for the future of both the gas and the coal industries. We have only 60 minutes, and I do not propose to occupy any more of them myself, on the assumption that some of you have done your homework. Those who have not will probably learn more from my critics when they get their teeth into my paper and tear it to pieces than they would from a hasty recapitulation of it by me.

Discussion

Sir HENRY JONES, M.B.E. (Chairman, The Gas Council):—I am very glad to have this opportunity of opening the discussion and I hope that Sir Harold will see that someone has done his homework, for I have given him a copy of what I shall say so that he can have some evidence of that. I am speaking, as is correct for one who speaks at such professional Institutions as this, as an individual, and my contribution does not purport to be more than an individual contribution.

The subject of the paper "The Choice of Subjects for Research and Development" is of prime importance to any major industry, but more especially to an old industry such as the gas industry, which has seen such changes in the past and must look forward to constant change in the future if it is to prosper.

Sir Harold Hartley is a man with a distinguished academic career in science at Oxford, including teaching and research; a gallant Service record and experience of chemical warfare in the First World War; directorships of the London, Midland and Scottish Railway Company and the Gas Light and Coke Company and many other important appointments, including some years as Chairman of the Fuel Research Board, all behind him; and today a connexion with a firm of chemical and constructional engineers that has worked for some time on a project for coal gasification. I have counted him as a friend since I first met him 36 years ago, and his paper is as valuable as one would expect from a man of his experience and ability.

His classification of research and development projects under three heads is interesting.

As he recognizes, one ever-present problem is to find the best distribution of the available effort over short-term and long-term objectives. It may be easy to find a desirable objective, perhaps the improvement of some existing process, of which it can be said that it is worth applying a given effort, expressed in terms of staff or money, for a given time, and to say also that it is not worth while going on if the results are not obtained within the time allotted.

When trying to discover new processes, or new knowledge upon which new processes can be based, the problem is much more difficult, especially as one knows that it may be years before anyone can say with certainty that the decision to begin or to continue any particular line of research was wise or unwise.

Sir Harold has referred to the time factor. I agree that things happen today more quickly, but at the same time many years often lie behind the development of some completely new material or new process even today. Some of these things take time to reach fruition.

The Gas Council is advised on research by its Research Committee, the membership of which includes eminent scientists.

Its research programme is designed, amongst other things, to lead to the improvement of existing processes and the discovery and development of new ones.

As the author indicates in Section VII, much effort has been directed to the development of new methods of gas production. Incidentally, his statement of the change in gas consumption between 1955 and 1959 makes the relative position of gas look a little worse than it is. The fall in consumption has been 2 per cent in four years, not 1 per cent per annum. Since 1st April, 1960, output has been more than 4 per cent above the 1959 quantity.

The research programme includes items expected to give a quick result, such as a pressure process for the production of peak-load gas from oil, and others longer term such as a gas-making process based on the hydrogenation of coal in a fluidized bed under pressure.

The Gas Council has also spent substantial sums on a search for natural gas in this country, and on developing a process, culminating in the successful *Methane Pioneer*, for carrying liquid methane by sea. This development is a joint project with Constock, the Council's American partners in this work.

Because of the importance of operating processes that require heavy capital outlay at a good load factor, while the demand for gas is highly seasonal, the Council is, as the author says, investigating possible sites for the underground storage of gas.

In a reference, in Section VII, to the work of Dr. F. J. Dent, the author mentions first the gasification of oil reported in 1956, and then Dent's work on coal.

Dent's work on the gasification of coal with oxygen under pressure, which began in 1935 in Leeds, and continued at Poole and now at Solihull, has been reported at frequent intervals ever since, most recently in his Coal Science Lecture, 1960.

Systems of coal gasification have been developed in this country and abroad, especially in Germany and the United States of America, but so far no developed process has appeared likely to give better results, using British coals, than the Lurgi process to which many of Dent's published papers refer.

The aim of the work over this 25-year period has been to produce town gas from coal by a process operated under a pressure of 20 or more atmospheres and incorporating a sufficient degree of enrichment by the hydrogenation of coal itself to render further enrichment of the gas unnecessary. To select only a few items from the reports of the former Gas Research Board, and Dent and his collaborators over the years, one can mention the gasification of coal in hydrogen reported, during 1937 and 1938, in the 41st and 43rd Reports of the Joint Research Committee of The Institution of Gas Engineers and the University of Leeds, and during 1943 to 1945 in the 4th, 5th and 7th Annual Reports of the Gas Research Board. The Annual Report of the Director of the Gas Research Board, 1947, refers to the hydrogenation of semi-coke, and the use of a fluidized bed in the reactor is foreshadowed. In the 53rd Report of the Joint Research Committee of the Gas Research Board and the University of Leeds (*GRB*40, published in 1948), work on the steam/carbon and carbon dioxide/carbon

* Report of the Committee on Coal Derivatives. (Ministry of Power; Cmd. 1120. H.M.S.O., 1960.)

reactions at high pressures, by Dr. A. Key, was reported, the effect of increased pressure on the rate of the steam/carbon reaction being much less than might have been expected.

In 1948 (*GRB*45/27), 1949 (*GRB*55) and 1950 (*GRB*60), experiments on the hydrogenation of semi-coke and coal in a fluidized bed were reported; *GRB*20 and *GRB*51 dealt with catalytic synthesis as a method of enrichment.

By 1952, The Gas Council had assumed direct responsibility for all research and had opened at Solihull the Midlands Research Station, of which Dr. Dent is Director, and in that year he presented a paper to this Institution (*GC*1) on the gasification programme, which included work on a pilot-scale Lurgi-type gasifier. In 1953, he reported (*GC*8) on experiments at Holten, in Germany, on the gasification of British coals in a small Lurgi gasifier. The National Coal Board collaborated in part of these experiments, some of which I witnessed. They covered Midland and Yorkshire deep-mined and Scottish open-cast coals. In 1954, the work on the pilot gasifier at Solihull was reported by Hebden, Edge and Foley (*GC*14), conditions inside the vessel having been examined by withdrawing samples of gas and recording temperatures at a number of different points. In 1958, Hebden and Edge reported on the successful operation of an experimental slagging gasifier at Solihull, working under a pressure of up to 75 lb/sq. in. gauge and using coke as a fuel.

This lengthy, but far from complete, account will correct any impression that work on coal gasification at Solihull has not been considered important. Work is also being done on oil, some of it for its own sake, some because many members of The Gas Council, including myself, believe, and have believed for some time, that the establishment of a satisfactory hydrogenation process for the production of gas from oil would help very much in the development of a process for the production of gas from coal by hydrogenation. I have mentioned the many years taken on some of this work, and if it is to achieve successful results it will need more time before these developments are fully established.

Work proceeding at Solihull includes (i) the redesign and reconstruction of the experimental slagging gasifier; (ii) the hydrogenation of coal in a fluidized system; (iii) the gasification of coal with steam and oxygen in a fluidized system; and (iv) the hydrogenation of oil, partly with a view to developing a similar system for coal.

In London, an experimental Otto Rummel slag bath gasifier is under construction, at a cost of some £210,000, for the study of a new low-pressure process for the gasification of powdered coal.

The Committee on Coal Derivatives (The Wilson Committee) has recommended that the development of a high-pressure slagging gasifier should be pursued. The Gas Council has welcomed this recommendation, and accepts that still more effort may have to be directed toward developing new processes for the gasification of coal.

In accepting that a slagging gasifier should be developed, one must emphasize that it has not been proved that it will be markedly more economical than a Lurgi generator with dry ash extraction, incorporating such improvements as may be introduced after experience of operation of Lurgi plants at Westfield and Coleshill. The author puts forward estimates of savings by the use of the slagging process, which one hopes are accurate forecasts. Their reliability, however, will not be established until a pilot slagging gasifier has operated on coal for a sufficient time for its performance to be evaluated and the economics of a full-scale installation to be assessed. In the interests of the gas industry, and the coal industry, too, work must be pressed on until this evaluation can be made.

The Wilson Committee gave some encouragement to the continuance of The Gas Council's work on coal hydrogenation. I feel that whilst the Lurgi plant now, and the slagging gasifier later, with enrichment by methane or oil gases, may be the best processes so far discovered for British coals, as a further development the gasification of coal by hydrogenation in a fluidized bed, as described by Dr. Dent in his Coal Science Lecture a few weeks ago, offers the prospect of an all-coal process for the manufacture of town gas. It seems reasonable to push the exothermic hydrogenation reaction as far as it will go before destroying the coal substance completely by gasification in steam and oxygen.

All that I can say today about the industrial gas grid referred to in Section XII is that a reasoned contribution might exceed the paper itself in length! The gas industry has, of course, long experience of supplying industrial consumers, some of them very large.

In Section IV, the phrase appears: "Mechanization reduces the price of some types of coal more than others". The prices at which the National Coal Board normally offers coal depend upon a number of technical and commercial considerations, but, so far as I am aware, not on the type of mining machinery used in the pit.

The cost, as opposed to price, must, of course, be greatly affected by mechanization, and the extent to which the future price of coal for gas making can be made to approach its cost is a matter for the National Coal Board. The decision of the Scottish Gas Board to proceed with the Westfield Lurgi plant was influenced by the price of coal available from the open-cast site nearby.

In Section VIII, the author pays a tribute to Mr. Campbell Secord. When first apprised some years ago of Mr. Secord's plans for a new type of gasifier, I said: "I shall always refer to this proposal as Secord's high-pressure blast furnace". He is certainly a most ingenious person.

Finally, some comment may be made on the author's reference, in Section VIII, to The Gas Council's evidence to the Wilson Committee. The Council, when considering the economics of any system of gas production, must look first and foremost at the price that the final consumer of the gas will be willing to pay to the Area Gas Boards. The prices quoted by the author, in Section VII, for coal, oils and gas, show what competition the industry has to meet.

Any process for gasifying coal or oil must, if it is to be adopted, offer the prospect of enabling gas to be sold at competitive prices.

In 1955, in an address to the Scottish Junior Gas Associations, when discussing gasification process, I said:—

> "The question of cost is of paramount importance. It is obvious that any process of gasifying coal or oil must result in the production of a therm of gas at a higher cost than that of the coal or oil from which the therm of gas is made, because it will require more than 1 therm of raw material to yield 1 therm of gas. It is always most dangerous to prophesy, but it seems to me doubtful whether a therm of gas can ever be made in this country by the gasification processes for less than twice the cost of a therm of coal or 1½ times the cost of a therm of oil. At present, I should regard both these targets as very difficult to achieve."

These were speculative remarks, but today they still make sense. Gas can be, and, of course, is, sold at prices above those of coal and heavy oil because of its convenience. The lower the price, however, the more is sold, and, having regard to load factors and costs of distribution, I feel that the figures quoted to the Wilson Committee call for no comment from me.

I can only say that I hope to see a successful coal gasifier developed, which, when fed with coal mined by the most modern methods, will play an important part in the future gas supplies of the country. Coal has certain handicaps when compared with oil as a feedstock for gasifiers—the need for conveyors, coal-preparation plant and equipment for ash extraction and disposal—but these should not be insuperable. Coal gasification and methane may be found to be very effective partners in future years. In the meantime, the gas industry is using such fully developed methods of gas production as it finds economic, and distributing its research effort in a manner that it believes to be appropriate in the interests of gas consumers.

In his closing section, the author relates the development of a coal-gasification process not only to the needs of the gas consumer, but to the position of the United Kingdom in world markets, and the balance of payments. This is not a subject that I can discuss today.

In closing, I thank the author for a paper in which the information given is extremely interesting, and the opinions expressed extremely stimulating.

Dr. D. T. A. TOWNEND, C.B.E. (Director-General, British Coal Utilisation Research Association):—Sir Henry Jones has commented very nicely on the gasification aspects of the paper. I shall lay a little more emphasis on some of its introductory material, which I find so particularly interesting.

I am sure that we have all read Sir Harold Hartley's paper with very great interest. I am sure that the first three sections provide a feast of anecdotes and illustrations of the manner in which inventions and developments have come about. Indeed, I am sure that these illustrations are new to us; they certainly are to me. They provide a brilliant exposition of the psychology of the research worker, and, indeed, the philosophy of science and the application of scientific work to practical affairs.

These three sections are particularly fascinating to those of us who are engaged in organizing industrial research, and there are, naturally, many points on which one would like to comment, but I shall just select one or two of them.

I think that most of the psychological problems in industrial research arise because scientists—at any rate, in traditional industries—work in comparative isolation. I think this is obviously a passing phase and will disappear as the elements of science and discovery become more part and parcel of our general education; but at the moment our professions seem to have become locked in quite artificially water-tight compartments.

If I may illustrate this, the mental processes of the scientist seem to have much in common with those of the lawyer; in economics, the laws of diminishing utility, *etc.*, have much in common with counterpart kinetic laws governing gaseous reactions; there is little basic difference mentally between quantitative chemical analysis and accountancy; and mathematics is a form of language employing shorthand symbols, and so on.

If versatility—I regard versatility as the hall mark of genius—were the aim of education, the present artificial professional demarcations should tend to disappear. In education, as in all things, the price of progress is eternal vigilance, and this holds particularly in countries like ours, depending on technical and commercial enterprise.

How true is Sir Harold's reference to Kettering, which runs as follows:

> "Kettering was critical of educational systems that taught the danger of failure. Failure to him was an opportunity of finding its cause. He said: 'You must learn how to fail intelligently . . . I can take any group of young people and teach them to be inventors, if I can get them to throw off the hazard of being afraid to fail'."

In this connexion, science seems to me to have become overglamorized—particularly since the advent of nuclear energy—for much of it is blood, sweat and tears. The commercial man cannot buy invention by employing scientists; he has to learn to create an atmosphere of calm and trust in which advances and inventions can best ensue. This is best achieved—pending better versatility in education—by the closest contact between all professional people, particularly those working together in one industry.

I particularly like Sir Harold's statement where he says that the greatest achievements in research are effected by a group of people working together remote from immediate projects—standing on on side, as it were, with time to think.

I had one or two other comments to make on the introductory remarks, but I feel that I must not detain you any further.

I have no particular comments to make on Sir Harold Hartley's concluding statements in regard to complete gasification. In fact, I would agree with most of them, having in mind what Sir Henry Jones has said about the Lurgi process itself.

The main issue nationally is that we have got to drift over the years to the use of refined fuels. If you like, better coal and oil research is the immediate national issue that we really want. We must not allow the coal industry to unwind too far during the period when oil is competitive and cheap.

You have heard previously that oil consumption in the United States of America is 600 imperial gal per head of the population per annum; it is 122 gal here, five in India and one in China, and the oil industry is catering for an expansion at the rate of 7 per cent annually, compound interest. But will China remain satisfied long with a consumption of 1 imperial gal per head of the population per annum compared with 600 gal in the United States of America?

The respective availabilities of oil and coal along these lines were discussed at a National Union of Mineworkers conference in March last, and a report has been published. There could be real risks, because it is thought that the oil industry might easily reach a peak output to meet demand in 20 to 25 years' time, after which it will decline, and we have to have in mind what is going to happen then.

On the question of gasification, I think I can wind up very quickly. I would think, personally, that the main thing is to establish gas grids because of the probable likely demand for lean gas—to which Sir Harold Hartley has referred—in industry. Last year I was at the Harrogate conference of the Combustion Engineering Association, and this was put to the section dealing with kilns and furnaces, and they made out a case concerning various gases. I asked whether, if they had a gas of 360 B.t.u./cu. ft at the right price piped to their works they would choose it as their fuel. I think there was a unanimous answer in the affirmative. This means that we ought to progress towards some sort of grid system, having in mind that we have a long way to go in the complete gasification of coal. I think it is right and proper for us to forge ahead as quickly as possible with the complete gasification of oil, and establish grid systems for industrial use at the same time. What is absolutely essential is that we must forge ahead having in mind the certain need in the not-too-distant years ahead when we can develop our newer coal-gasification processes.

Lastly, I would mention the fascinating prospects of the use of industrial gas. Those who attended the Fuel Luncheon Club at the last meeting will have listened with fascination to Dr. Burns's account of what he saw of the exploitation of natural gas in Russia. The Russians are getting more and more natural gas. They are going to exploit it while the going is good, and they will do so to the relegation of their coal industry. Dr. Burns mentioned how the Russians are piping natural gas into the middle of Moscow and putting their power stations there. This is very encouraging and is one of the research objectives of the future. If power stations can be brought away from the pithead and into the centre of the cities and the fuel pumped to them, it is possible to avoid the transport costs of coal or oil, to avoid the cost of ash removal, and to avoid the very difficult problem of boiler availability. Also, the cost of transmission of gas is cheaper than the cost of transmission of electricity. So, bring the power stations into the middle of cities and use the commerical gas.

Then there is the possibility of pressurizing boilers, and so on. This is an enthralling point, and on this note I end.

I would say again how very much we have enjoyed the paper.

Dr. L. ROTHERHAM (Member of Research and Development Board, Central Electricity Generating Board):—Sir Harold has said that members of the Institution would be more interested in hearing his critics than in hearing him speak. I feel that there will not be many critics, but I think he will be satisfied with a commentary rather than a criticism. I wish to comment on the different types of research activity to which he refers in the paper, because there is still a good deal of misunderstanding on this subject.

The three types of activity can roughly be divided into what is called pure research, development, and what is described in the paper as trouble shooting. In most people's minds, there is a feeling that if one proceeds from one to the other one is going downhill rather fast. I do not believe this for a moment, but it is worth noting what are the differences between these types of activity.

I do not think there is such a thing as pure research—certainly, nothing as pure as some people believe pure research to be; certainly, it does not exist in the ordinary industrial laboratory. I prefer to think of it as a deep or concentrated activity, the kind of pursuit that can be engaged in by one brilliant man who normally will be very expert in one or other of the tools of science, either mathematics or the experiment and the process of thinking about the result. Sir Harold does

not think that this kind of work is likely to lead to a major break-through, but I do not entirely agree. I think that the major break-through, the complete revolution, in technology is likely to come from this kind of activity, and some part of the work of the industrial laboratory has to be of this type.

In development, there is more than one type of development, but ordinarily one passes through the stage of assembling the data from the deep activity, and often one passes through pilot plants and large and expensive installations. Although Sir Harold has said that numerical appraisal of the relative merits of different projects is not a good thing, any development for use on a large scale is such that numerical appraisal of the cost is never far from people's minds in deciding exactly the cost of operation. Most of the work should be done on a small scale, even when dealing with development, but the technique of carrying it out, even on a small scale, is usually that a number of people are working together on similar problems. They must be prepared to work together, so that there is a co-operative and group activity immediately arising at this stage in research and development, which is not necessarily true of the pure research stage. Consequently one cannot tolerate a large-brain type of prima donna when this stage of the activities is reached, and this is even more true when one emerges to the scale at which large sums of capital may be envisaged.

Trouble shooting is the third type of activity, and the best people for trouble shooting are those with experience as well as the tools of science, which are experiment and mathematics. I do not think that people ought to be ashamed of being experienced. This is a very high form of activity, and the most versatile type of all, and, if versatility is a sign of genius, then probably these are the closest to genius of those in any research activity.

To return to the question of numerical appraisals, the first numerical appraisal that has to be made, and which is often consciously made, is to divide the research activity of an organization into these different categories; it is extremely important that it should be done. I admit that one does not ordinarily have to bother to appraise the first category; one has enough trouble getting anybody to do this kind of activity. But a full organization requires all the activities, and I, therefore, believe that there is a case for some form of numerical assessment. Certainly, there are types of people, of whom I am one, to whom an assessment of this kind is satisfying in reinforcing a judgment that may have been formed emotionally rather than rationally.

However, I agree fully with Sir Harold that, in spite of this slight difference in emphasis, the main element in deciding what is a suitable subject for research is the judgment of the senior staff, who are responsible for carrying it out.

At this point, I want to make a brief reference to the second part of the paper, and a brief comment on it. I do not believe in the use of a Committee. I am not being unduly critical of the Wilson Committee when I say this, but I do not believe in the use of a Committee to determine what is a suitable subject for research; I do not believe that this is a good idea. The Wilson Committee arrived at some very sensible conclusions, and it did so on the advice provided by a number of people who appeared before it. Normally, the people who provided the advice—I am thinking specifically of research directors—provided information and advice in which they believed very passionately, and all that the Wilson Committee has done, I hope, is to reinforce the passionate beliefs of the people who provided the evidence. On the whole, it has done this, and for that reason its members have provided a good Report. If they had discouraged the people who were responsible for carrying out research and had differed materially from the views advanced in that way, it might have been a bad Report. I do not believe that a Committee, no matter how eminent, is a substitute for a good head of establishment, who believes in what he is doing and intends to do it.

The conclusion that I have reached, therefore, is that, in selecting subjects for research and development, any enlightened management chooses first a suitable head of establishment. Having done this, they say to him: "You choose the subjects for research"; and then forget about it for a while until the results begin to come forth. On the whole, this is the theme that Sir Harold has been trying to develop in his paper.

Mr. CAMPBELL SECORD (Constructors John Brown, Limited):—It gives me much pleasure to add my congratulations to Sir Harold and to welcome the shrewd wisdom embodied in his paper. I have the privilege of working with him as a colleague on just such problems, and I can vouch for the practical way in which that wisdom is always applied. I should like to add one or two footnotes to the paper, the first being a bit of a fable.

I have been convinced, since about 1950, that modern processes for coal gasification could play a key part in this country's future fuel supplies, and that there was room for much more technical work to improve efficiency. In order to justify pilot development of pressurized slagging gas producers, the Ministry nominated a foster-parent in the guise of oil synthesis, which, I think, was fair enough in the "pre-Suez" days.* The twin children have grown slowly, but they show promise; and recently they have been legitimized by the Wilson Committee. Meanwhile, the foster-parent has been drowned in a flood of oil. But, no doubt, new parents will be found to adopt the slagging orphans.

The moral of this story, to my mind, is clear—a successful development must have a proud and prosperous parent, as well as an economically sound objective, wisely and imaginatively chosen, and an enthusiastic sense of purpose and urgency, qualities so rightly emphasized by Sir Harold.

If I may become a little political for the moment at a Research Meeting, I should like to touch on what, to me, is a very serious risk that major projects like gasification can run into if their prosecution diverts attention from immediate practical issues or is even made an excuse for inaction. This can give rise to a most serious situation. Coal gasification is one of the central issues of fuel policy; how to influence the investment and price policies of the four giant fuel industries, so that gas can be made from coal on a much larger scale and at a price competitive with oil for the chief heating loads, in order to meet consumers' insistent and proper preference for fluid fuels, and at the same time preserve a stable outlet for our indigenous coal.

This objective does not depend at all upon further technical advances. A 1 mill. ton Lurgi scheme in a 50:50 combination with light hydrocarbons can, I believe, supply town gas to London for 8*d.*/therm; this is quite as cheap as any straight hydrocarbon scheme based on reforming, and better than oil gasification or carbonization methods.

The 8*d.* that I quote is lower than the cost given by the Wilson Committee, for three reasons: first, the Lurgi figures can be improved by recent developments, including hot shift, and I believe that the efficiency achievable is more like 62 per cent gas—coal yield overall rather than the 52 per cent implied by the Wilson Committee figures; secondly, liquefied petroleum gas, or, I trust, methane is available at 6*d.*/therm, not at 7½*d.*; thirdly, there are, I believe, combinations of lean coal gas and enriched hydrocarbon gas in the proportion of 50:50, rather than the 37:63 quoted in the Report, and it must be controlled in regard to both enrichment therms and very considerable additional therms for the purpose of winter heat.

It is only by the early adoption of several further big Lurgi projects that the future of coal gasification can be firmly established, alongside the widespread current shift to hydrocarbon feedstocks. This requires a truly national initiative, which will take time to mount. But I believe that now is the time to initiate at least a third Lurgi project on a larger scale than those already in train, large enough to achieve a thoroughly competitive price and so to support a highly promotional tariff designed to increase demand in step with supply; and large enough, also, to justify a start upon big pipelines from coalfields to major load centres.

Far from depending on technical developments to get Lurgi costs down another 1*d.* to 2*d.*/therm, the reverse is nearer the truth, that several big Lurgi plants built now are the only sound basis for their further development. This business of by how much one can reduce costs by means of further development is a much-trodden and muddy field, but I think it is important, and I should like to explain briefly my own point of view about it.

* The speaker was referring to the Suez Canal crisis of July, 1956.

I believe that the prize to be got by further development of the Lurgi process, primarily by slagging, but also by many other opportunities for improvement, is more like 2*d.*/therm than the 1*d.*/therm Sir Harold concedes to it in his paper. This is for two reasons.

The first is that the improvement of gas yield and blast steam requirements obtainable by slagging are more or less agreed, and on this performance the cost saved on steam, including carbon monoxide-shift, and coal, less net by-product revenue, can be shown to be about 1*d.*/therm.

The second is that the therms of gas produced per actual cubic foot of wet raw gas will be about 76 per cent higher with slagging; but I am personally convinced that it will also be possible and profitable to operate slagging gasifiers with much higher actual gas velocities, giving unit outputs at least three times higher, and reducing costs by a further 1*d.*/therm. I base this opinion primarily on the limited, but suggestive, evidence that slagging coke gasifiers have been run at atmospheric pressure at carbon ratings as high as the maximum reported for the Lurgi process at 25 atmospheres.

In my view, the possibility of making "impure hydrogen" from coal for a price near 6*d.*/therm is very important. On the one hand, it promises great scope for highly promotional and competitive sale of town gas, with an increasing edge over reformed hydrocarbons. Also, it encourages serious consideration for use in new types of peak power plants, such as fuel cells, for gaseous reduction of suitable iron ores, and for chemical synthesis. Incidentally, when, and only when, lean coal gas is cheaper than rich hydrocarbon gas will there be a strong incentive to increase its calorific value to 500 B.t.u/cu. ft or better by going to very high pressures or to a two-stage hydrogenation process.

Mr. J. E. DAVIS, O.B.E. (Technical Officer, South Eastern Gas Board):—When so highly respected a teacher and counsellor as the author of this paper brings from his rich store of experience guidance to help us in looking squarely at our problems, it would be presumptuous to praise, and brash to criticize. We do better to express our gratitude and apply ourselves to learning the lessons which this Communication sets before us.

The section headed "First Aid"—a pleasant alternative to the more brutal "trouble shooting"—is especially valuable in dealing with the relationship between the practical engineer and the research man. If this is understood, it should bring help to the former and entice the latter out of the castellated security of his ivory tower.

Sir Harold used the word "serendipity"! But really this is not a gift bestowed on the infant researcher by a fairy godmother. Its possession requires that the experimenter shall be willing to experiment and able to recognize the unexpected when it appears. To this must be added a disciplined imagination which sees in the unexpected an opportunity of practical usefulness. I believe this is a good recipe, but the ingredients are far from easy to come by.

Sir Harold Hartley has given us four very interesting examples—the zip fastener, printed circuits, tubular scaffolding, and silicones—which have taken very many years from their invention to practical application, a matter to which Sir Henry Jones has referred. Sometimes they had to await the final link of a chain. More often they had to await a change in external circumstances which compelled their use. The research man is always out of date, but with the reverse algebraic sign to the practical man. The practical operator is necessarily behind the times by about the half-life of the capital equipment he is using. The research man must be at least an equal distance ahead of the times.

The research programme which the author surveys was in essence recognized as necessary at least a quarter of a century ago. The low cost of gas transmission compared with coal transport or electricity transmission was then recognized. Coal gasification at the pithead instead of coal carbonization locally was even then defined as a research objective. The convenience of liquid methane as a means of conveying and storing heat energy was experimented with in 1940, but all these things seemed wild dreams, or even nightmare freaks until these last few years. Why has the climate changed?

In his conclusion, the author refers to three energy industries, presumably coal, gas and electricity. But what of the fourth—oil? It is surely this newcomer which has compelled our urgent interest in new methods of coal processing and made the former dreams appear as urgent necessities. I wonder, if that fourth member were magically removed or legally hampered, would we be nearly so keen on finding a solution to these problems of using coal cleanly, conveniently and efficiently?

The challenge of this paper will, I am sure, be taken up by practical men of affairs as well as by research workers, and I trust that therein Sir Harold Hartley will find the evidence of gratitude for stimulating our thoughts.

Mr. G. LE B. DIAMOND, C.B.E. (Chairman, West Midlands Gas Board):—All members of the Institution will, I am sure, be stimulated by Sir Harold Hartley's masterly review of recent scientific progress and the unfolding of his logical ideas in the choice of subjects for research and development.

It is evident that Sir Harold is an admirer of that great American inventive genius, Charles Kettering, to whom we owe a debt of grattitude every time we press the self-starter on a motor-car. The work of Kettering is known to the older generations of research workers, but his biography, which was published only a few years ago, should be read by all who have not yet read it.

Naturally, I was interested in Sir Harold's observations on the Lurgi plant. Also, the words of Mr. Secord were very refreshing indeed to us in the West Midlands, for in 1951, when we started on our project, we were told that we had backed the wrong horse. I am glad that Sir Harold has mentioned that he had made no allowance in his figures of cost for recent improvements planned in the Ruhrgas plant at Dorsten, for the latter are most encouraging. The steam-cooling of the grates in substitution for the former system of water-cooling has resulted in a marked upward trend in efficiency, for formerly large quantities of uncontrolled water were being converted into steam through leakage from the water-cooled grates. This added water was in addition to the steam normally injected. In consequence, the effluent liquor has been reduced by no less than 35 per cent on the former water-cooling system. The most interesting factor of all, however, is the introduction, by Dr. Weittenhiller, of the Ruhrgas carbon monoxide conversion plant, which appears to be a complete success. It makes use of the steam entrained with the gas at the outlet of the generators for shift reaction and abolishes the need for the manufacture of steam for this purpose.

Sir Harold has some very pertinent remarks to make about the development of the slagging gasifier, and rightly points out that the great advantage of this system is that it uses a wider variety of coals. Indeed, it is one of the methods that we have at present available of being able to gasify really low-grade coals with a low ash melting-point, but there are formidable engineering problems to be overcome before the slagging gasifier can be accepted as a practical proposition.

In view of the shortage of time, I am shortening my contribution, but there are one or two remarks that I want to make on what has been said in very thoughtful contributions by Sir Henry Jones and Mr. Secord.

I am sure that Mr. Secord is right about the possibility of producing a therm of gas from the Lurgi process even cheaper than we have estimated. We have always known that that possibility exists. What is worrving me is whether we can get the Lurgi plant going in the Midlands in time. There is a very big mass attack being mounted behind the scenes to introduce liquid gases to our larger industries—there is no doubt about this at all—and we must compete with it with cheaper gas for the larger industries. We can do it with the Lurgi plant, but can we get it in time?

Dr. Townend has given us a clue. Some members will remember the time when Lancashire was in trouble years ago—it has again been in trouble recently—through not being able to sell textiles abroad, and it was said: "If only we could get another shilling a week into a Chinaman's pocket, it would set all Lancashire going." This is the problem today; we have to get that shilling into the Chinaman's pocket so that he can buy this liquid gas..

Mr. H. D. GREENWOOD (Deputy Director of Carbonization, National Coal Board):—I have read the first part of Sir Harold Hartley's paper with the keenest interest and appreciation of his treatment of this difficult problem of the initiation and direction of research. Sir Harold has concentrated his views on future research in the gas industry mainly on the gasification of coal. He takes as a basis the report of the Wilson Committee.

This Committee gave the estimated costs of gas in a large Lurgi plant as 8·59*d*/therm, or 8·9*d*. delivered to London. It is suggested in the paper that, with the latest known improvements in the process, the cost could be reduced to 7·5*d*./therm *ex*-works. Whilst I think the reduction of 1*d*./therm may perhaps be a little on the high side in relation to the latest German techniques, there are further possible methods of reducing the costs.

The cost as quoted by the Wilson Committee includes, I believe, additional boiler power plant supplying power to the grid. This would be eliminated if the coal were supplied exactly to requirements, as it would be in practice. Higher throughput per generator could be obtained by using different sizes of coal in different generators; higher-ash coals could be used, and these have usually a lower fusion-point, so that less steam would be required. If the plant were large enough, the larger-diameter generator might be used, thereby reducing costs. Improved methods of removal of carbon dioxide are being examined, and I feel that there is scope for improvement in this and in other sections of the purification plant. The Lurgi plant has been regarded primarily as a base-load plant, but, with adequate supplies of butane it could be used economically for peak loads, as is done in Germany.

The Wilson Committee considered in some detail advantages and disadvantages of slagging operations, and concluded that this should lead to a significant reduction in the cost of gasifying coal. The Wilson Committee, however, had not made allowance for the improved techniques in the non-slagging process, which were subsequently developed at Dorsten.

Sir Harold suggests that by the slagging operation the cost of lean gas might be reduced by about 1*d*./therm, which would reduce the cost of the enriched gas to about 8*d*./therm. He has indicated that the improved technique at Dorsten could reduce costs by about 1*d*./therm. I am not sure whether it is suggested that the whole of the further improvement that might be obtained by slagging is in addition to these improvements made at Dorsten. In considering the advantage of slagging, we must not forget that the carbon monoxide content is considerably increased and that the cost of removal is, therefore, greater.

There is no doubt, however, that the development of the slagging technique could result in a further and indeed significant improvement in cost and might well result in the final cost of the enriched gas being under 7·5*d*/therm on a large plant.

From these various examinations of the possibilities of improving the efficiency and reducing the cost of the Lurgi process, two conclusions may be drawn. First, there is still considerable scope for improvement in the existing process. This is an immediate problem. Secondly, further improvement could be obtained by slagging. This is a longer-term development, but detailed studies of some of the problems involved and some experimental work are necessary to assess more accurately what can be gained by slagging.

Sir Harold has briefly considered the idea, put forward by the Wilson Committee, of having a separate supply of lean industrial gas with the minimum of purification, and has suggested that this might allow cost to be cut a further 1*d*./therm. If this gas were supplied direct to industry, it could presumably be enriched and transmission costs thereby reduced.

The subject of Sir Harold's paper is "The Choice of Subjects for Research and Development". May I, in conclusion, suggest that, in view of "the importance of the national issues at stake in the future of coal"—to quote the paper—the possibilities of making a really cheap gas by the gasification of coal should be given the highest priority in future programmes for research and development.

Dr. J. BURNS, G.M. (Deputy Chairman, North Thames Gas Board):—I am glad to be able to take part in the discussion, first, because it enables me to express my admiration for Sir Harold Hartley and his paper, and, secondly, because we have with us our friends from the electricity industry.

My short theme is transportation of energy. We see ourselves divided into 12 local Area Gas Boards with a local distribution system and not a single 150,000 V transporter between us—not a single trunk main; and we see the electricity industry entirely gridded from one end of the country to the other.

We should not be too despondent about this. We recognize that the electricity industry had to build up its grids at a time when it was carrying on with the same type of electricity production, whereas we of the gas industry at the present time have a glorious opportunity to build a new grid to fit in with new methods of gas production—and this is very important. We should not be too hard on ourselves either about not putting in grids before now, because the transportation of energy relationships have changed only in the last decade—in the post-war years—and it is only during these last few years that it has been cheaper to carry the products of gas production rather than the raw materials. But now is the time when the transportation of the products is cheaper, and we should now see to it that our new distribution systems are based on this.

Cheap though the transportation of our products may be, we must be very careful that we do not carry out any unnecessary transportation. I am prompted in this remark by the possibility of making gas in the Midlands and carrying it to London at 8*d*./therm in a combination of Lurgi process and liquid methane, the liquid methane contributed to the extent of 6*d*./therm. This methane would come from London. One asks why one should transport liquid methane to the Midlands at 6*d*. in order to send it back to London at 8½*d*. This is just a superficial appreciation, however, but we have all to be very careful that our economics are fundamental, basic and right.

I take Sir Harold up on one point only—the distribution of the lean industrial gas. Why should we transport it? It is much cheaper to transport a rich gas. Obviously, a mains transmission system is cheaper. Lean industrial gas will only be distributed if it is very much cheaper than rich industrial gas.

Written Contributions

Mr. L. W. ANDREW (Director, Watson House Centre) wrote:—In Section III of his paper, Sir Harold refers to the value of first aid. At Watson House, we agree with his assessment. I hope he will agree, however, that, with a research team of reasonable size, it should be possible to keep one or two members of the team completely isolated from interruption.

In Section IV, reference is made to incentives; in the gas industry, the most important single factor is competition from other fuels, particularly electricity. In our assessment of projects for research and development—and one cannot separate them—we have two concepts clearly in mind: first, to make fuller use of the basic advantages of gas of speed, flexibility and flame; and to minimize the disadvantages of flueing, the need for ignition and the potential corrosion of heat exchangers. Secondly, we aim to provide a better service than our competitors at an improvement in overall economy from the point of view of capital, installation and running costs.

I was sorry to see that Sir Harold omitted from this section the name of Mr. G. C. Holliday, who played such an important part in building up Watson House as a research centre under conditions of nationalization.

In Section V, Sir Harold touches on the most exciting part of our work. This internal excitement is not always fully appreciated by those who are not familiar with utilization research. It is normally a complicated route from an idea to a commercially available new appliance or new technique, and there are many very important fingers in the pie. Often, we trigger off a new concept of utilization and provide the basic technical knowledge as a sure foundation on which this can be exploited. It is normally wrong to think of one piece of work and the final product. There is more likely to be continuing research and development, to which many people contribute and out of which arise designs and projects that may look very different from the original. Perhaps I might quote two specific examples: the one referring to balanced-flue appliances, and the use of common balanced flues. The idea of a balanced-flue appliance dated back in primitive form to 20 years or so before the Second World War. Shortly before the war, it seemed to us

at Watson House that the principle needed fundamental development, and, as a result, prototypes were made up for space heaters and water heaters and discussed with manufacturers. The new idea of a common balanced flue was a logical step and was initiated at Watson House after the war. A paper was given to The Institution of Gas Engineers in 1953, and further papers have been given since then; one presented at the 26th Autumn Research Meeting shows the practical impact of common flues and the continuing research work to establish them and develop them in the best and simplest forms. On high-efficiency convector gas fires, the idea of a long narrow radiating unit to place in front of a coke fire led to the possibility of superimposing a high-efficiency heat exchanger, and the next step is the concept of a closed-type high-efficiency fire. The final product in each case will be a co-operative effort with the appliance manufacturers. The fundamental work will, however, continue.

In Section VI, Sir Harold makes a very interesting suggestion concerning the availability of a small team without responsibility for any one particular project. It may be that such an idea is particularly suited to a very large research establishment, or to one in which the operating units are scattered. We operate an alternative system at Watson House, in which one senior person becomes responsible for a laboratory dealing with a complete heat service, i.e., the testing, development and research problems associated with that service. This results in the availability of eight key men, and it seems to me that I can rely on these key people to operate in a somewhat similar manner to the small panel to which Sir Harold refers. We have also the advantage of the Gas Council Research Committee, which considers from a more detailed and highly intellectual point of view the research programme and the progress of research work.

In Section VII and onwards, the author refers to future research projects for the gas industry, and I am sorry that he did not include research on gas utilization. I hope he will agree that utilization projects may not appear, as single items, to be on such a large scale, but the ultimate effect of changes in utilization should lead to what is, in effect, a decrease in cost of useful therm and open the way to the industry to take full advantage of the existing developments also taking place in gas manufacture.

Finally, a factor of very great importance is the morale of any research and development team. All workers must feel that they are part of a team; they must know the real value of their work and see results from it. Their work should give them scientific status as well as recognition in the gas industry, and they must know that, even if the results of their work are not always recognizable, they are accepted as having made a worthwhile contribution to the industry.

Again, I thank Sir Harold Hartley for such a stimulating and interesting paper.

Mr. K. W. FRANCOMBE (Whessoe, Limited, Darlington) wrote:—I should like to ask Sir Harold whether he would support the view that invention is increasingly becoming the prerogative of the specialist? I refer to the type of invention exemplified in the current patent literature of the gas industry.

The need for invention and development is now usually known only to those with a prolonged knowledge and experience of the particular industry involved. The required parameters of such inventions can be fully understood only by those with such an intimate knowledge. As a result, their task becomes clearly defined and the invention is logically evolved to suit the requirements.

I have heard it suggested that what might be described as the "virgin brain", confronted by the problems unsolved by specialists and considering them entirely afresh, may have flashes of inspiration which no longer come to the "jaded" minds of those more intimately concerned, but I think this rarely applies.

In similar context, I have heard disappointment expressed that the Wilson Committee, largely composed of people from outside the gas industry (with one distinguished exception), was unable to point to some entirely new and unexploited fields of research and development on coal derivatives. However, I would have thought this most unlikely and that the Committee amply fulfilled its function in so clearly setting out the state of the existing knowledge and suggesting the most promising lines to pursue.

I think it improbable that a newcomer to the gas industry, with all its 20th Century knowledge and experience, could suggest any likely new fields of progress until he had thoroughly absorbed that which had gone before. Would Sir Harold agree?

Mr. G. U. HOPTON (Gas Council London Research Station):—Sir Harold Hartley's paper covers a very wide range and possesses a breadth of outlook that only he, with a lifetime of experience in academic and industrial research and an insight into both pure and applied science, could achieve. I propose to confine my remarks to the actual choice of research subjects.

As Sir Harold says, many subjects choose themselves; they do so in four main ways:—

(1) Certain processes are obviously undesirable for one reason or another, for example, excessive demand for labour, high capital or running costs, unpleasant working conditions, health hazards, or nuisance. An example of this kind of problem is the work that has been done on oxide purification.

(2) Even processes reasonably satisfactory at one time can be seen, on close study, to be capable of modification and improvement in the light of new scientific and technological knowledge. One should never omit to take out one's most treasured possessions from time to time and give them a good dusting over.

(3) Changing conditions, such as availability or price of raw materials, make a change in processes necessary. This sort of consideration has led to research on the gasification of coal and of oil. The Deputy Chairman of The Gas Council began an article on "A Changing Pattern of Gas Manufacture", in the *Financial Times* of 15th November, 1960, with this sentence: "A future historian of the gas industry may reasonably conclude that a decision taken some 10 years ago, whereby a premium value was attached to coking property in the coal price structure, marked the beginning of a revolution in the technology of gas manufacture".

(4) There is the ever-present drive to give consumers better service. On the production side, an example is the research now being put into the problem of reducing the carbon monoxide content of gas.

The above remarks may seem obvious, but what I want to emphasize is that research can be carried out on many of these projects, not only on a "try-it-and-see" basis, such as passing oil and steam over different kinds of catalyst and measuring the gas yield, but also on a fundamental basis, namely, the mechanism of the chemisorption of the reacting molecules on the catalyst surface, and changes in the nature of the catalyst surface. The type of work that can be done depends very much on the time available. In my experience, if an answer is wanted quickly, it is necessary to go ahead by simulating as well as one can the conditions likely to apply in practice and obtain experimental results without going too deeply into the basic aspect of the reactions involved, fascinating though they may be. If the difficulty that is being tackled is ever likely to be of some duration in the industry, and I think we may say with certainty that catalysts will be needed in one process or another for many years, then fundamental research must be done also. Similarly, even if a particular problem in gas washing is solved fairly quickly, it is certain that problems of mass transfer with chemical reaction will be with us in one form or another and therefore fundamental research must be carried out in this subject.

One might almost say, therefore, that certain fundamental research projects choose themselves. What is so difficult is to choose long-term fundamental research. Who knows what conditions will be in, say, 10 years' time? In my view, the choice of such projects needs the most careful consideration, taking into account research not only in our own industry but in all allied fields. There is, I believe, need for ever greater collaboration with research work everywhere. Only by keeping in the closest possible touch with work done by the Area Gas Boards, by the contractors, by others in the fuel industries and in academic circles can we hope to see a little further into the future than we have sometimes done in the past.

Dr. J. G. KING, O.B.E. (London) wrote:—I feel that it is a great privilege that we should be addressed by so eminent a leader in the scientific world as Sir Harold Hartley. I feel also that the value of his address is not so much to this audience only as to the leaders of research in our industry. The principles that he lays down in the first five sections of his paper are not, perhaps, wholly new to us in that they are the accepted procedures of research administration, but, as stated by Sir Harold, and as exampled from his wide experience, they call attention very clearly to the need for wisdom in research management.

From my own experience, I would pick out two of the factors as of special significance. The first is the position in the research team of the man of inventive genius. He certainly has a real place there, but he should never be allowed to disturb the main effort of the research department unless or until his invention has shown, by severe trial, that it would pay to sacrifice older projects in its favour. The necessary severe trial should not, however, be delayed, or something valuable might be lost: this calls for good judgment by the team leader. Sir Harold has given several examples of this, but there must be many others. (For example, silicone products, which are so important today, really had for birthplace the University of Nottingham, but in the development stage were lost to the United States of America.)

The second factor is the wise evaluation of a research project at different stages of progress in order that unproductive work may be cut off as soon as it ceases to show promise. The ability to do this effectively is a true index of research leadership that is not emphasized by Sir Harold, but which is not given to many. It is interesting to recall that probably the first reference to a research subject as a project dates back as far as Dean Swift (1667 to 1745). His character Gulliver, who was a Cambridge graduate, describes the projectors of the academies of Lagado, who were busily engaged upon a variety of investigations, but were not stopped by a lack of success but, "instead of being discouraged were 50 times more violently bent upon prosecuting their schemes, driven equally by hope and despair". These were perhaps academic, not industrial researches, but the research leader of today would do well to be alive to this warning from the past.

In the later sections of his paper, Sir Harold takes the gas industry as his subject and reviews the active projects of production, storage, and distribution of gas, and, in the light of the recommendations of the Wilson Committee and of his own wide experience, makes a number of proposals for the immediate future of research and development in the gas industry.

In view of the great importance of the wider application of town gas in both domestic and industrial fields, he might have given us the benefit of his advice there also. It is certainly important to reduce production costs, but research into new applications, particularly to industry, could be even more important.

In his discussion of the Lurgi process, he points out that the cost of enrichment is an important economic factor. In the early work of the former Gas Research Board, the direct production of a gas of high calorific value was considered to be an important factor. It was thought that it should be possible to favour methane production by operation at a higher pressure than the 25 atmospheres used in the gasification of brown coal. This was indeed demonstrated in the development stage, but, although pioneer work was done in the Ruhr by the Lurgi Company, the difficulties of realizing this with bituminous coal have not been overcome.

This does not mean that they cannot be overcome if the effort made were to be intensified. The Wilson Report places the responsibility for gasification projects upon the gas industry only, but, in view of the prime importance of coal quality in both the Lurgi and the slagging-gasifier processes, I suggest that it might have been wiser to have enlarged the responsibility to include the National Coal Board and to have widened the scope of the development work. In his conclusions Sir Harold would seem to agree with this view in comparing unfavourably the amount of money to be spent on methods of gasification with that spent in the field of nuclear energy. Perhaps this point will arise in the House of Commons when the report comes up for discussion: if it does, one could hope that his further wish for an expanded national fuel policy could be brought up again. This has been suggested several times already and was actually recommended by the House of Lords in 1958, but was denied by the Minister. One method of advancing the position must be to accelerate research on coal and coal processing, and one could hope that this address would not only be a guiding light to the gas industry in this field, but also inspire national action. In thanking Sir Harold for his address, we should all hope that it will do so.

Dr. R. J. MORLEY (Director of Carbonization, National Coal Board) wrote:—I suggest two important matters might be added to Sir Harold Hartley's excellent presentation of the criteria and motives underlying the choice of projects for research and development in industrial laboratories.

The first is the importance of leadership. In this field of research and development more than any other, how necessary it is to have the right leader; a man with plenty of ideas of his own and able to grasp the significance of other peoples ideas, but with the judgment and experience to sort them out into priorities; a man with plenty of drive, able to command the respect of his team, and with the determination to follow through with his beliefs against all obstacles, technical, financial and political.

The second is the importance of doing actual practical work in the chosen field. Paper studies are fine and fundamental work in the laboratory is essential, but few processes, when they get on to the semi-technical or pilot-plant scale, work out exactly as envisaged. Not infrequently, knowledge emerging from the pilot plant gives just that twist to the process essential for its successful commercial application, sometimes in a direction quite different from that originally envisaged. A notable example is the contribution made to the store of technological knowledge in this country by the production of synthetic oil by the high-pressure hydrogenation of coal, which paid such handsome dividends during the Second World War in the production of aviation petrol, and in the post-war years in the development of high-pressure processes involving reactions between (variously) hydrogen, carbon monoxide and other gases with olefines and other hydrocarbons; all this was despite the original goal—the manufacture of oil from coal on an economic basis—having been abandoned meanwhile. It is no accident that Germany has produced so many fine gasification processes: it was the result of a considerable effort on the plant scale (not merely in the laboratory), and at the expense of the failures of some processes that successes of outstanding practical importance were eventually achieved.

There are lessons here for all of us, suggesting the need for firmness in conception and for boldness in execution.

Written Reply

The AUTHOR, in reply, wrote:—I am surprised that the discussion has turned so largely on the early part of my paper, which I thought was uncontroversial. Perhaps it is not surprising as the Wilson Report is still *sub judice*, and, no doubt, many people were unable to discuss some of the important issues about the future of gas and coal that I raised towards the end.

My critics and commentators were very kind to my diagnosis of the mainsprings of research and development, but they raised a number of interesting points to which I must reply. Mr. Rotherham suggested that it was my opinion that concentrated effort by one brilliant man in a specialized field was unlikely to lead to a major break-through. May I quote my own words:—

> "While the individual inventor, the man with the creative imagination to foresee new means of meeting human needs, or, indeed, of inducing new needs by his creations, still plays an important rôle, unquestionably the rapid advance of scientific knowledge has prompted many of the most significant inventions in recent years. . . ."

Later on, I quote in support of this the researches that led up to nuclear power, the electronic valve, penicillin, and silicones. I did not perhaps emphasize sufficiently the contrast between fundamental research pursued in the quest of new knowledge and applied research in which that knowledge is utilized for some practical end. These two fields call for rather different types of mind, and both are essential for the economic future of the United Kingdom and the Common-

wealth. I rate them of equal value. The old prejudice against applied research, to which Mr. Rotherham referred, is, I believe, dying fast, and the sooner it is dead the better. I was glad that Mr. Andrew spoke of the excitement attaching to utilization research. It can be just as satisfying as the pure variety, and nothing is more thrilling than to watch the building of a great plant made possible by laboratory studies.

Mr. Andrew took me to task for not having referred to research on gas utilization, but in Section XII I did mention a number of new fields which industrial gas may enter, and I had applied research much in mind when I appealed in Section XIII for greater financial support for gasification development. I am glad that he reminded us of the contributions made by the late G. C. Holliday at Watson House in the early days of nationalization. The omission of his name was all the less excusable on my part as, like Masterman, he was one of my pupils at Balliol.

Mr. Francombe asks whether I think that invention is becoming more and more the prerogative of the specialist. My reply to Mr. Rotherham was directed to this point and, while agreeing with Mr. Francombe that the fresh knowledge on which some new invention can be based is likely to come from a specialist, the idea of applying it may well occur to someone with a broader horizon. I remember a prominent industrialist saying to me that in his experience "if a young man didn't produce a bright idea before he had been three years with his firm, he was unlikely to do so later". The fact is that some individuals have an inventive turn of mind; they are never satisfied with leaving things as they are. They are not always easy colleagues to work with, but they can be most valuable if their ideas get sympathetic treatment and are subjected to what they would agree was fair criticism. Invention is a field in which it is dangerous to generalize.

Mr. Hopton stressed the difficulty of choosing long-term fundamental research in an industrial laboratory and the need to keep a watchful eye on the whole field of scientific research. This latter task is becoming increasingly difficult with the rapid increase in the number of research workers in the universities, in Government laboratories and in industry, and the huge number of specialist journals. An intelligence service is essential in the organization of an industrial research department. Francis Bacon in his *New Atlantis* foresaw the varied functions of such an organization. His merchants of light and depredators were his intelligence service, and his dowry men or benefactors "bend themselves, looking into the experiments of their fellows, and cast about how to draw out of them things of use and practice for man's life and knowledge".

I agree with the importance that Dr. King attached both to the delicate handling of the man of inventive genius and to the need to shut down a programme when it has ceased to show promise. My General in France once said to me: "The worst of you scientists is that you never know when to cut your losses". Perhaps we have learnt something since 1918, though I still notice some reluctance to recognize a hard fact.

Dr. Morley stressed the importance of leadership in an industrial laboratory, and with that, of course, I agree. As Mr. Rotherham pointed out, a committee is no substitute for individual leadership and must not be allowed to prejudice its freedom.

I turn now to the remarks on the second part of my paper, which dealt mainly with the Wilson Report. I hope that Sir Henry Jones did not think that I was grudging in my appreciation of the results of the research programme of The Gas Council, with which I had to deal rather summarily. The ingenuity and resourcefulness of Dr. Dent's contribution over many years is something that we all admire. Of course, I agree with Sir Henry that, until we have a new type of gasifier operating on full scale, it is idle to try to evaluate the contributions that it may make to the industry. However, as Mr. Secord pointed out, as well as Mr. Diamond, the Lurgi process is well established and the value of the new developments at Dorsten described by Mr. Diamond have been proved in practice. There is, therefore, no reason for delaying the building of further Lurgi plants on the coal fields, on the ground that the slagging gasifier might in the future prove superior. The decision must depend on the cost of gas production as compared with other methods, and in this the price of suitable coal will be a large factor. Such a development, as Dr. Burns pointed out, would be the first step towards a national high-pressure gas grid. I cannot agree with Dr. Townend's suggestion that we should go ahead as quickly as possible with the complete gasification of oil, while waiting for the development of new processes for the gasification of coal. I was glad that Dr. Townend agreed with me as to the bright future for industrial gas.

In pressing for the building of a third still larger Lurgi plant, Mr. Secord gave some good reasons why the cost of Lurgi gas quoted in the Wilson Report and in my paper was on the high side, and all the points he raised will no doubt be taken into account in any future evaluation of its possibilities.

Mr. Davis takes me to task for referring to three energy industries to the exclusion of oil. I should, of course, have added the word "nationalized" before "energy industries" to make the meaning of the sentence in Section XIII clear. There was, I hope, no lack of appreciation in my paper of the importance of oil and its products, and the challenge that it represents for gas and coal. As regards his reference to serendipity, Horace Walpole's heroes "were always making discoveries, by accident or sagacity, of things they were not in quest of". The discovery of the unexpected is, of course, one of the justifications and romances of research, and, as Dr. King pointed out, the value of a research may extend far beyond the field in which it began.

Mr. Diamond rightly emphasized the need to drive ahead as quickly as possible with Lurgi plants as a counter to the effort to sell more and more liquid petroleum gas to our larger industries. He reiterated the improvements in the original Lurgi process which made him optimistic about selling cheaper gas. Mr. Greenwood supported him in this and backed my own plea for high priority for research and development in the fields of gasification, which was reinforced again by Dr. King in calling for an accelerated research programme on coal and coal processing.

As the Wilson Report is still *sub judice*, my paper did not provoke quite such a free discussion of the immediate problems facing the gas and coal industries as I had hoped for. However, I trust that the issues I have raised will not be forgotten when the recommendations of the Report are debated.

21st REPORT OF THE CHAIRMEN'S TECHNICAL COMMITTEE: 1959-60

COMMUNICATION No. 577

The Chairmen's Technical Committee has pleasure in submitting its 21st Report to the Council of The Institution of Gas Engineers.

D. D. MELVIN,
Chairman, Chairmen's Technical Committee.

W. T. K. BRAUNHOLTZ,
Secretary, The Institution of Gas Engineers.

17, GROSVENOR CRESCENT,
LONDON, S.W.1.

3rd October, 1960.

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TECHNICAL COMMITTEES OF THE INSTITUTION OF GAS ENGINEERS

The membership of the technical Committees of The Institution of Gas Engineers at the time of submitting this Report is as follows:—

Chairmen's Technical Committee

D. D. Melvin (*Chairman*); F. L. Atkin, M.I.Mech.E.; T. C. Battersby, M.B.E., M.I.Mech.E.; J. E. Davis, O.B.E.; F.R.I.C.; G. le B. Diamond, C.B.E., M.I.Mech.E.; A. V. Horsfall; Chairman, British Standards Institution Gas Industry Standards Committee (G. E. Currier, O.B.E., M.I.Mech.E.).

Ex Officio: The President, the two Vice-Presidents and the Honorary Secretary of the Institution.

Codes of Practice Sub-Committee

J. E. Davis, O.B.E., F.R.I.C. (*Chairman*); M. O. Coates; J. E. Cooper, B.Sc.; F. G. Craxford; A. Harrison; W. T. Hird, M.B.E.; A. McFadyen; R. S. Taylor; C. Wadsworth; the Chairman of each drafting Panel; H. A. R. Binney, C.B. (representing the British Standards Institution); Director of Building Research (representing the Department of Scientific and Industrial Research); G. Fairweather, F.R.I.B.A. (representing the Royal Institute of British Architects); B. Svenson (representing the Building Industries National Council).

Drafting Panels

PANEL A (Connexions to Mains, Gas Service Pipes, Control Valves or Cocks).—F. L. Atkin, M.I.Mech.E. (*Chairman*); A. L. Allen, B.A.; F. Bell, B.Sc.; K. E. Brown; A. H. Berry, A.I.A.S.; A. D. L. Copp, M.I.C.E.; R. O. Emmony; G. Fairweather, F.R.I.B.A.; T. W. Gibson; W. T. Hird, M.B.E.; T. W. Jackson; R. H. O'Neill; E. W. Pickering; W. H. B. Porter; Royal Incorporation of Architects in Scotland; N. T. Wait.

PANEL B (Meters and Connexions, Consumers' Installation Pipes).—N. Hudson, M.B.E. (*Chairman*)); C. R. Austen; A. H. Berry, A.I.A.S.; G. Fairweather, F.R.I.B.A.; E. S. Harris; R. N. Le Fevre, M.B.E.; G. W. Emrys-Roberts, T.D.; Royal Incorporation of Architects in Scotland; C. H. Smith; T. Smith.

PANEL C (Gas Lighting).—A. G. R. Farr (*Chairman*); A. H. Berry, A.I.A.S.; J. B. Carne, B.Sc.; G. Fairweather, F.R.I.B.A.; Royal Incorporation of Architects in Scotland; P. Crawford Sugg, B.Sc.(Eng.); F. C. Smith, M.B.E.; D. M. Thompson.

PANEL D (Hot Water Supply by Gas).—G. H. Fuidge, B.Sc. (*Chairman*); A. H. Berry, A.I.A.S.; L. J. Coles; F. Craven; G. Fairweather, F.R.I.B.A.; D. C. Henderson; F. Kay, M.A.; J. W. Pringle; C. H. Purkis, B.A., B.Sc.; N. W. Rickwood; Royal Incorporation of Architects in Scotland.

PANEL E1 (Space Heating).—D. R. Wills, B.Sc. (*Chairman*); A. H. Berry, A.I.A.S.; F. Craven; G. Fairweather, F.R.I.B.A.; F. Kay, M.A.; W. J. Parsons; Royal Incorporation of Architects in Scotland.

PANEL E2 (Cooking including, Catering Equipment, Refrigeration).—E. W. B. Dunning, B.Sc. (*Chairman*); A. H. Berry, A.I.A.S.; P. N. Carpmael; G. Fairweather, F.R.I.B.A.; J. H. Gibbons; F. Lake, B.Sc.; W. J. Parsons; Royal Incorporation of Architects in Scotland.

PANEL E3 (Central Heating by Hot Water).—W. F. Moore; (*Chairman*); A. H. Berry, A.I.A.S. A. D. Billingham; E. G. Brooks; G. Fairweather, F.R.I.B.A.; W. F. Howell; W. J. Parsons; C. H. Purkis, B.A., B.Sc.; Royal Incorporation of Architects in Scotland.

PANEL F (Flues for Gas Appliances).—F. J. Eaton, Ph.D., B.Sc. (*Chairman*); A. H. Berry, A.I.A.S.; H. A. Blum; J. B. Carne, B.Sc.; J. Churton; G. Fairweather, F.R.I.B.A.; A. V. Horsfall; S. Perriss; H. K. Reichert, Dr.(Ing.); W. J. Wadey; Royal Incorporation of Architects in Scotland.

PANEL G (Gas-heated Appliances for Laundering and Ancillary Domestic Purposes).—G. H. Fuidge, B.Sc. (*Chairman*); W. F. Andrews; A. H. Berry, A.I.A.S.; G. Fairweather, F.R.I.B.A.; J. W. Pringle; C. H. Purkis, B.A., B.Sc.; Royal Incorporation of Architects in Scotland.

Gas Distribution Committee

F. L. Atkin, M.I.Mech.E. (*Chairman*); A. L. Allen, B.A.; F. Bell, B.Sc.; K. E. Brown,; A. D. L. Copp M.I.C.E.; R. O. Emmony; T. W. Gibson; W. T. Hird, M.B.E.; T. W. Jackson; R. H. O'Neill; E. W. Pickering; W. H. B. Porter; N. T. Wait.

Ex Officio: The President, the two Vice-Presidents and the Honorary Secretary of the Institution.

Gas Works Effluents Committee

G. le B. Diamond, C.B.E., M.I.Mech.E. (*Chairman*); E. H. M. Badger, B.A., F.R.I.C.; G. E. Currier, O.B.E., M.I.Mech.E.; J. H. Dyde, O.B.E., M.Sc., M.I.Chem.E.; E. T. Pickering, B.Sc., F.R.I.C.; W. F. Thorne, B.Sc.; P. Wedgwood, M.Sc., F.R.I.C.

Gas Works Safety Rules Committee

T. C. Battersby, M.B.E., M.I.Mech.E. (*Chairman*); D. W. Ault, B.Sc.(Eng.); F. C. Barker; H. F. Buxton, B.Sc.(Eng.); T. A. Canning; H. S. Cheetham, M.I.Mech.E.; J. E. Davis, O.B.E., F.R.I.C.; J. E. Dixon; H. G. Hall; W. K. Hardie, B.A.; L. Hartley, M.I.Mech.E.; F. K. Illingworth, B.Sc.; H. Moys, B.Sc.(Eng.), A.M.I.C.E.; G. F. Oliver, M.B.E.; A. G. Palmer, M.B.E., B.Sc.; R. G. Plummer, B.Sc.(Eng.); T. S. Ricketts; G. M. Rimmer, M.Sc.(Eng.), A.M.I.E.E.; H. J. Victory, B.Sc.; H. Wadsworth, B.Sc.; S. L. Wright, B.Sc.

Ex Officio: The President, the two Vice-Presidents and the Honorary Secretary of the Institution.

Co-opted: Hedley Parker, B.A.

Meters Committee

Area Gas Board Nominees: A. V. Horsfall (*Chairman*); J. E. Brandon; K. E. Brown; B. G. H. Clegg, M.A.; J. E. Cooper, B.Sc.; J. Dean; T. N. Dent; C. P. Henshilwood, B.Sc.; W. T. Hird, M.B.E.; W. Mottram; H. A. Sawyer; C. H. Smith.

Society of British Gas Industries Nominees: H. Adcock; E. Butterworth; R. D. Gaskin; J. P. Smith; E. J. Spurrier; W. K. Tate, M. A.; H. Thompson; W. D. Wilson, B.E.M.

Institution of Gas Engineers Nominee: C. R. Austen.

Ad hoc Committee on Electrical Bonding

T. C. Battersby, M.B.E., M.I.Mech.E. (*Chairman*); F. Bell, B.Sc.; H. F. Buxton, B.Sc.(Eng.); J. E. Cooper, B.Sc.; A. D. L. Copp, M.I.C.E.; J. E. Davis, O.B.E., F.R.I.C.; W. A. Fitzsimons, B.Sc.(Eng.); R. D. Gaskin; W. T. Hird, M.B.E.; N. Hudson, M.B.E.; H. Moys, B.Sc.(Eng.); G. F. Oliver, M.B.E.; C. H. Purkis, B.A., B.Sc.; T. S. Ricketts; G. M. Rimmer, M.Sc.(Eng.), A.M.I.E.E.; W. E. G. Robinson, B.Sc.(Eng.).

Committee on Unaccounted-for Gas

A. V. Horsfall (*Chairman*); L. W. Andrew, B.A., B.Sc.; F. L. Atkin; C. R. Austen; F. Bell, B.Sc.; B. G. H. Clegg, M.A.; C. P. Henshilwood, B.Sc.

Chairmen's Technical Committee

The Chairmen's Technical Committee of the Institution is responsible to the Council for the co-ordination of the work of the standing technical Committees and of *ad hoc* Committees or Panels appointed for particular purposes. The 21st Report contains accounts of the work of all these Committees during the last 12 months. It also includes, as supplements, memoranda or recommendations prepared by the various Committees and approved by the Council for publication.

The Report further contains short accounts of the work of the Ninth Arthur Duckham Fellow (Mr. J. H. Elliott, M.Sc.), the third Dempster Travelling Fellow (Mr. E. Thornton, M.Sc.) and a statement concerning the Institution Gas Research Fellowship.

The Technical Committees have throughout the year maintained close liaison with the appropriate Government Departments and with kindred organizations including the British Standards Institution, the Parliamentary and Scientific Committee, the Joint Committee on Non-destructive Testing and the Engineering Applications Group of the British Conference on Automation and Computation.

Reference is made later in this Report to the Committee on Unaccounted-for Gas, which was appointed by the Council in October, 1959, "to study the problem of unaccounted-for gas in all its aspects and to recommend ways of reducing it".

The Institution has continued to collaborate actively in the work of the International Gas Union and its standing Committees. The following represent the Institution on the Council and standing Committees of the Union:—

Council.—Mr. W. K. Hutchison, C.B.E.; Dr. J. Burns, G.M. B.Sc.; Dr. W. T. K. Braunholtz, O.B.E. (*Honorary Secretary*).

Committee on Harmonization of Essential Clauses in the Specifications for Stamping Gas Appliances.—Mr. L. W. Andrew, B.A., B.Sc.; Mr. F. Lake, B.Sc.

Vocabulary Committee.—Dr. W. T. K. Braunholtz, O.B.E.

Committee on Statistics.—Mr. C. Johnson.

Committee for the Study of New Gas Distribution Techniques—Mr. W. K. Hutchison, C.B.E. (*Chairman*); Dr. J. Burns, G.M. B.Sc.; Mr. D. L. Copp; Mr. A. G. Higgins, M.Sc. (*Secretary*).

Working Party on the Code of Practice for Safety in the Construction of International Pipelines for Gas Transport.—Mr. D. L. Copp.

Committee for the Study of the Interchangeability of Gases.—Mr G. H. Fuidge, B.Sc.; Mr. J. A. Prigg, B.Sc.

Committee on Safety Conditions in Domestic Commercial and Industrial Gas Installations.—Mr. G. E. Currier, O.B.E. (*Chairman*); Mr. L. W. Andrew, B.A., B.Sc.; Mr. A. G. Higgins, M.Sc. (*Secretary*).

Working Party on the Composition of Gas in relation to its Safe Utilization.—Mr. G. E. Currier,O.B.E. (*Chairman*); Mr. W. B. S. Newling, M.A.; Mr. A. G. Higgins, M.Sc. (*Secretary*).

Reports from all the above-mentioned Committees will be presented and discussed at the Eighth International Gas Conference which is to be held in Stockholm on 27th to 30th June, 1961. There will also be reports prepared by the Gas Associations of member countries as a result of an international enquiry, and in this connexion The Institution of Gas Engineers will be responsible for reports on:—

(1) Further Study of Unconventional Flues.

(2) Further Study of the Use of Petroleum Products for the Production of Town Gas.

In addition, the following individual papers will be presented, under the aegis of The Institution of Gas Engineers and discussed:—

(1) "Heat Services by Gas in Houses and Flats", by L. W. Andrew and D. R. Wills.

(2) "Liquid Methane: A Review", by J. Burns, G.M., and L. J. Clark, B.E.M.

(3) "Developments in Industrial Gas Utilization", by R. F. Hayman and W. A. Simmonds.

A joint meeting of members of The Institution of Gas Engineers and of The Coke Oven Managers' Association and the British Coke Research Association was held at The Institution of Civil Engineers, on 11th November, 1959, when a paper, entitled "The First Year at the Coke Research Centre", was presented by Mr. G. W. Lee, M.Sc., Director, British Coke Research Association. The chair was taken by Sir Frederick Scopes, M.A.

The next joint meeting of the three organizations is to be held in the Hoare Memorial Hall, The Church House, Westminster, on 2nd November, 1960, when a paper on "The Coke Oven—Retrospect and Prospect", will be given by D. T. Barritt, B.Sc., and V. Robinson, M.A.

The Parliamentary and Scientific Committee arranged a conversazione in the headquarters of The Royal Society, Burlington House, on 9th December, 1959, in connexion with which an exhibition on the general theme "Science in Everyday Life" was arranged. The Institution of Gas Engineers collaborated with The Institute of Fuel, The Institute of Petroleum, the Electrical Research Association, the British Coal Utilisation Research Association and The Institution of Heating and Ventilating Engineers in staging an exhibit on "Comfort and Health in the Home".

The Institution was represented at the National Fire Protection Conference, held in London on 25th and 26th February, 1960, by Mr. G. H. Fuidge, B.Sc., and Mr. W. K. Hardie, B.Sc., and at the Fuel Efficiency and Power for Industry Exhibition, held at Olympia, on 27th April to 6th May, 1960, by Mr. R. F. Hayman, B.Sc.

At the invitation of the Royal Institute of British Architects, members of the Institution attended a meeting of the Institute on 8th March, 1960, and took part in the discussion of a paper entitled "The Profession in Contemporary Society", by W. A. Allen.

Mr. A. C. Rea represented the Institution at the Annual Conference of the Royal Society of Health, held at Torquay on 25th to 29th April, 1960, at which a paper sponsored by the Institution, entitled "The Use of Modern Gas Equipment in Blocks of Flats and other Large Buildings", was presented by Mr. D. R. Wills, B.Sc., and Mr. N. R. Junkison.

A joint symposium on "The Protection of Gas Plant and Equipment from Corrosion", arranged by The Institution of Gas Engineers, the Corrosion Group of the Society of Chemical Industry, and the College of Advanced Technology, Birmingham, was held at the College on 22nd and 23rd September, 1960. The President, Mr. H. S. Cheetham, took the chair at the opening session, and at other sessions, the Chairman of the West Midlands Gas Board (Mr. G. le B. Diamond, C.B.E.) and the Chairman of the East Midlands Gas Board (Mr. R. S. Johnson, M.B.E.) presided.

The Institution is participating in the Public Works and Municipal Services Congress at Olympia on 14th to 19th November, 1960. A session is to be held under the chairmanship of the President of the Institution (Mr. H. S. Cheetham), at which the two under-mentioned papers will be presented and discussed:—

(1) "Unusual Engineering Problems Encountered in Laying Gas Pipelines", by F. Bell, B.Sc.

(2) "Space and Water Heating Equipment to Conform with the Requirement of the Clean Air Act", by W. H. Welch.

The following have been appointed to represent The Institution of Gas Engineers on the undermentioned Committees of the British Standards Institution:—

Standards

Mr. D. R. Wills, B.Sc. (in succession to Mr. B. W. B. Dunning, B.Sc., resigned).—SFE/30 (Hospital Incinerators).

Mr. J. H. Wylde.—RPE/1/1 (Secretariat Sub-Committee (I.S.O.) on Refractories).

Mr. C. H. Purkis, B.A., B.Sc. (in succession to Mr. T. G. Noble, resigned).—SFE/6 (Chimneys and Flues).

Miss N. Farrow, B.Sc.—New Sub-Committee on Chromatographic Analysis of Gases.

Mr. A. B. Densham.—SFE/17/7 (Paramagnetic and Infra-red Methods of Gas Analysis).

Codes of Practice

Dr. F. J. Eaton, B.Sc. (in succession to Mr. J. E. Davis, O.B.E., resigned).—Council for Codes of Practice.

Mr. F. Bell, B.Sc., and Mr. J. W. Chilver, B.Sc.—CVCP/8 (Code of Practice on Prevention of Steel Corrosion).

Dr. F. J. Eaton, B.Sc.—BLCP (Codes of Practice for Buildings).

Codes of Practice Sub-committee

The Council of the Institution recently decided that, in view of the importance of the codes of practice in connexion with the domestic utilization of gas, all Area Gas Boards should be represented on the Codes of Practice Sub-Committee. Accordingly, an invitation was sent to those Area Gas Boards not already represented on the Committee to appoint representatives. The full membership of the Committee, including the newly appointed representatives, is given on page 2 of this Report.

The Codes of Practice Sub-Committee and its drafting Panels have continued throughout the year the work of revising and bringing up to date the codes of practice that were initially prepared some 11 to 13 years ago. Until this revision became desirable, it had not been necessary to convene some of the drafting Panels, and in the meantime there had been retirement of some members and changes in occupations and responsibilities of others, necessitating some revision of the membership of the Panels. The Institution desires to thank all those gentlemen who, for one reason or another, are no longer able to serve on the drafting Panels, for their services in the past, and to welcome those who have kindly agreed to succeed them. The present membership of the drafting Panels is given on page 2 of this Report, and it is particularly desired to refer to the appointment of Mr. G. H. Fuidge, B.Sc., and Mr. W. F. Moore as Chairmen of Panels D and E3 respectively in succession to Mr. L. W. Andrew, B.A., B.Sc., and Mr. W. J. Parsons, who have both, through increased responsibility, found it necessary to resign. Mr. Parsons, however, has agreed to continue to serve as a member of the Panel.

In view of the close connexion between the code on Flues for Gas Appliances and the Building By-laws, it was felt desirable to strengthen the membership of Panel F, which is responsible for this code, by inviting representation from the London County Council, the Ministry of Housing and Local Government and the Building Research Station. Mr. W. J. Wadey, of the Architects Department of the London County Council, and Mr. J. Churton, of the Building Research Station, have been appointed to the Panel in response to this request, and Mr. K. R. Lack, of the Ministry of Housing and Local Government, while unable to serve on the Panel, has kindly agreed to study and comment upon the revised draft.

Earlier Reports of the Chairmen's Technical Committee have referred to the liaison that has been established in connexion with the preparation and revision of codes of practice with the Royal Institute of British Architects, the Incorporated Association of Architects and Surveyors, and the Royal Incorporation of Architects in Scotland. The co-operation of these organizations continues to be of great assistance to the drafting Panels.

Panel D was pleased, at the request of the Council, to consider and comment on the Model By-laws (Series XXI) for the prevention of waste, *etc.*, of water, which are being revised by the Ministry of Housing and Local Government.

The Institution is represented on the Council for Codes of Practice for Buildings and the Committee for Codes of Practice for Mechanical Engineering.

The present position in regard to the revision of codes of practice is as follows:—

(i) Gas Service Pipes.—Revised code prepared by Panel A was published in November, 1957.

(ii) Gas Installation Pipes and Gas Metering and Consumers Control. —Revised drafts have been prepared by Panel B, but further action is temporarily suspended pending negotiations with the Institutions of Electrical and of Water Engineers in regard to the recommendations of the *ad hoc* Committee on Electrical Bonding. (See p. 7.)

(iii) Domestic Hot Water Supply by Gas.—Panel D is in the course of re-writing this code.

(iv) Gas Cooking Installations (Single-family Dwellings). —The revised code prepared by Panel E2 has been circulated by the British Standards Institution for comment.

Gas Cooking Installations (School Meals).—A suggestion has been received from the Ministry of Education in regard to the revision of the code, which is now being considered by the Panel.

(v) Space Heating by Means of Independent Gas Appliances.—Panel E1 has under consideration the comments submitted on the revised draft code, which was circulated to industry in April, 1960.

(vi) Flues for Gas Appliances.—A revised code prepared by Panel F is now in general circulation for comment.

(vii) Installation of Gas-heated Appliances for Laundering and Ancillary Domestic Purposes.—The revised code, amended in the light of comments received, is now being printed by the British Standards Institution.

Gas Distribution Committee

The Committee has received with regret the resignations of Lt.-Col. J. A. Gould, M.C., Mr. C. R. Monroe, and Mr. G. F. Siddall. Lt.-Col. Gould joined the former Pipes Committee in 1948 and was appointed chairman in succession to Mr. H. J. Escreet, B.Sc.(Eng), in 1954. He resigned from the chairmanship upon his retirement from the gas industry in 1957, but agreed to continue to serve on the Committee. Lt.-Col. Gould's contributions to the work of the Gas Distribution Committee and its predecessor, the Pipes Committee, have been very considerable and the indebtedness of the Institution is gratefully acknowledged.

Mr. Monroe and Mr. Siddall, also, have been members of the Committee for a number of years, and the Institution records its appreciation of their services.

Mr. R. H. O'Neill has been appointed to the Committee as the representative of the North Eastern Gas Board.

One of the meetings of the Committee during the year was held at the works of Metal Economics (Seaguard), Limited, Silverstone, when the opportunity was taken of demonstrating to the Committee the coating of steel tubes with an epoxy coal tar material. The process is still in the development stage and certain difficulties have yet to be overcome, particularly in connexion with pipes of small diameter, but, in the view of some members of the Committee, the process has distinct possibilities, and the Committee will watch progress with considerable interest.

The Committee expresses its appreciation of the arrangements made by the Company for this visit and demonstration.

The publication entitled "Recommendations for the Laying of Steel Gas Service Pipes" prepared by the Committee has been issued as a separate *Communication* (*No.* 563) during the year. It is intended as a companion to "Recommendations for Mainlaying" (*Communication No.* 491), and it is hoped that the general adoption and implementation of the recommendations will lead to a higher standard of service laying.

The Committee continues with the assistance and co-operation of the Area Gas Boards to collect and collate data concerning fractures in cast iron mains and the conditions under which they occur. It is also collecting information in much greater detail of every incident arising from leakages from mains or services leading to personal injury, fire or explosion. The number of such incidents since this particular investigation was commenced has not been sufficient for any general conclusions to be deduced, but the Committee is continuing with this work.

Meanwhile, as was reported in the 19th Report of the Chairmen's Technical Committee (*Communication No.* 532), an independent research on fractures of cast iron mains has been carried out by Mr. J. Power under the direction of The Gas Council's Scientific Adviser, Sir Charles Ellis, F.R.S. Sir Charles and Mr. Power have now reported to The Gas Council, and the report has been made available to the Committee.

It is of interest to note that many of the aspects to which the Committee drew attention in its report to The Gas Council in January, 1958, have been confirmed by this research. Thus, for example, emphasis is placed on the complex nature of the age/fracture relationship, the evidence clearly suggesting that age of main alone should not be used as a guide to the need for relaying. The importance of good distribution practice, co-operation with other public utilities and the avoidance of long small-diameter pipes, which were all referred to in the Committee's report, are also features of the conclusions arrived at by Mr. Power and Sir Charles Ellis. They have referred to the potential value of mains and services surveys. This is a matter that is being closely studied by the Committee and upon which it will report when it has further information available. In the meantime, it might perhaps be stated that while such surveys, which are costly to conduct, do make some contribution in locating fractures of long duration, they are not likely to contribute greatly in solving the difficulties associated with ground movement accompanying severe weather conditions such as prolonged periods of frost or drought.

The Panel appointed by the Gas Distribution Committee to consider the external protection of steel pipes has continued its investigations in collaboration with the manufacturers of steel pipes and the suppliers of coating materials and with the Coal Tar Research Association. Its report, which should be regarded as a further interim report, since its work is still being actively pursued, is reproduced as Supplement I to this Report.

The use of plastic materials for the manufacture of pipes, especially for gas service pipes, is receiving attention in this country and abroad. These materials are in general highly resistant to attack by materials that are very corrosive to steel, and for this reason their use is attractive to distribution engineers. Unfortunately, they are susceptible to certain compounds, particularly aromatic hydrocarbons, which are found in most manufactured gases. A number of experimental installations have, however, been installed in various parts of the country and the Committee will study their behaviour and performance. In the meantime, the Committee has endeavoured to summarize the information available in a report that is included as Supplement II to this Report. The subject has also been studied on an international basis by the Committee of the International Gas Union for the Study of New Gas Distribution Techniques, which has reported to the Council of the Union.

The present position in regard to the use of plastic pipes may briefly be summarized as follows:—

(*a*) Plastic pipes show a high degree of resistance to external attack by materials found in most subsoils.

(*b*) They are light, easily transportable and easily jointed.

(*c*) Plastic pipes are being used for the conveyance of natural gas and appear to be giving satisfactory results. Very limited use and experience has, however, been gained from plastic pipes conveying manufactured gases, and research is being undertaken as to the extent to which the latest developments in polyvinyl chloride will withstand the aromatic hydrocarbons existing in these gases.

(*d*) Their use for internal installations is not recommended in some countries because of the fire risk.

Should it be possible to overcome the problems referred to in (*c*) and (*d*) above, the use of plastic pipes would probably be considerably and rapidly extended.

The Cast Iron Pipes Liaison Committee has continued to meet throughout the year. Mr. D. L. Copp has replaced Lt.-Col. J. A. Gould, M.C., as a representative of the Gas Distribution Committee on the Committee. The Committee has prepared a brochure entitled "Recommendations for the Transportation, Handling and Storage of Cast Iron Pipes", which has been published as a separate *Communication* (*No.* 575) of the Institution.

Other matters that the Cast Iron Pipes Liaison Committee has under consideration include (i) the revision of the British Standard 78 (Cast Iron Pipes (Vertically Cast) for Water, Gas and Sewage and Special Castings for Use Therewith), with particular reference to the inclusion therein of the new I.G.E. siphon, which was produced by the manufacturers in collaboration with the Committee; (ii) inspection procedure during manufacture of cast iron mains.

The Gas Distribution Committee was pleased to collaborate by supplying replies to a questionnaire on cathodic protection, which was prepared by the German Association of Gas and Water Engineers. This Association is studying the subject on an international basis and will present a report thereon at the 8th International Gas Conference, to be held in Stockholm, in June, 1961.

The Committee was consulted by the Legal Adviser of The Gas Council in regard to powers now being sought by many local authorities to operate cleansing vehicles on pavements and footways. The Committee's view is that there must obviously be an element of risk or damage to buried gas plant by the operation of cleansing vehicles on pavements and footpaths but, providing the weight does not exceed 1 ton, the risk is slight. Local authorities proposing to use vehicles on such pavements and footpaths in excess of 1 ton should consult the undertakers having apparatus in the district that might be affected by such use.

Gas Works Effluents Committee

The Committee acknowledges with appreciation the valuable services of Mr. F. C. Snelling, who served on the Committee for many years and who recently retired from the Gas Industry.

In the 20th Report of the Chairmen's Technical Committee, the appointment was reported of a small Sub-Committee, comprising Mr. E. T. Pickering, B.Sc. (*Chairman*), Dr. W. H. Blackburn and Mr. W. F. Thorne, B.Sc., to investigate and report to the Gas Works Effluents Committee upon the various processes that have been installed in recent years for the biological purification of Gas Works effluent in the

absence of sewage. This investigation was initiated with the object of providing advice in the case of gas-making plant being erected at a place where no ready outlet for the effluent, in admixture with sewage, is available. The Sub-Committee has inspected pilot- and full-scale plants operating all the known biological processes developed by the carbonizing industries or in connexion with effluents derived from the treatment of the by-products of gas manufacture. The information collected is being reviewed for submission to the main Committee.

The main Committee has itself visited the Saltley Works (including the installation of 48 laboratory-scale filters), a joint enterprise of the Birmingham Tame and Rea District Drainage Board and the West Midlands Gas Board. They have also inspected the new sludge digestion plant at the Minworth works of the Drainage Board and the effluent treatment plants at the Four Ashes works of Midland Tar Distillers, Limited. To all the undertakings providing facilities for these visits and the accompanying discussions the Committee desires to express its warm appreciation for their helpful co-operation.

The Committee has noted with interest the publication by H.M. Stationery Office, in 1958, of the First Report of the Trade Effluents Sub-Committee (Chairman: Sir Frederick Armer) of the Central Advisory Water Committee of the Ministry of Housing and Local Government, to which the Institution had submitted written evidence. This Sub-Committee was appointed to examine, *inter alia*, "the position respecting section 8(2) of the Rivers (Prevention of Pollution) Act, 1951, which requires the consent of the Minister before a river board may take proceedings under section 2 or section 3 of that Act, and to advise whether it is desirable to suggest the extension of the operation of that provision beyond the term of seven years from the passing of the Act and, if so, for that further period". In its Report, the Sub-Committee concludes that it is desirable that a little extra time should be given to industry to pursue research on effluent treatment and to river boards for the preparation of by-laws and to lay down standards governing the quality of effluents and it therefore recommends that the original seven-year period be extended by three years.

The Committee wishes to draw attention to the following publications on effluent disposal:—

(1) Paper entitled "An Investigation of the Effect on Effluent Disposal of the Electro-detarring of Hot Gas", by W. H. Blackburn, M.Sc., Ph.D., M.Inst.Gas.E., S.P.; M. Kershaw, B.Sc., A.M.Inst.F., and J. R. Catchpole, B.Sc. (*Gas Council Research Communication GC*60), presented and discussed at the 25th Autumn Research Meeting of The Institution of Gas Engineers.

(2) Paper entitled "Investigation and Treatment of Trade Effluents", by F. G. Broughall, B.Sc., F.R.I.C., R. B. Evans, B.Sc., F.R.I.C., and P. H. Garnett, A.R.I.C., presented at a meeting of the Midland Branch of the Institute of Sewage Purification, in Birmingham, on 25th November, 1959.

(3) Booklet entitled "Nitrogenous Liquor as a Fertilizer", by F. Clifton Sherriff. (Published by the National Association of Agricultural Contractors.)

The Committee has continued to maintain close co-operation with The Gas Council's Liquor Effluents Committee and with the Ammonia Effluents Sub-Committee of the Joint Research Committee of The Gas Council and the University of Leeds.

Gas Works Safety Rules Committee

The Councils of The Institution of Gas Engineers and of The Coke Oven Managers' Association have for some years considered from time to time ways and means of effecting closer collaboration between the two organizations whose aims and objects have much in common. The work of the Gas Works Safety Rules Committee is one field where co-operation is most valuable, for many of the hazards with which the Committee is concerned are common to both gas works and coke oven works, and, indeed, the I.G.E. Safety Recommendations are adopted, where appropriate, by the managements of most large coking plants. Accordingly, it was a matter of considerable satisfaction to the Committee to welcome two new members appointed, at the invitation of the Institution's Council, by the Council of The Coke Oven Managers' Association as its representatives. The Association has selected one coke oven manager from the coal industry, Mr. F. Illingworth, B.Sc., and the other from the steel industry, Mr. H. J. Victory, B.Sc. Both are in their own rights Members of the Institution.

As a result of some serious accidents in coal and coke bunkers, the Committee has given consideration to the preparation of recommendations in regard to the means of "Safe Access to Hoppers and Bunkers". These recommendations were published in March, 1960, as I.G.E. Safety Recommendation M11, and are included as Supplement III to this Report.

During recent years, there has been a considerable extension of the gasification of heavy oils in catalytic plants. All petroleum crude oils contain vanadium compounds to a greater or less extent according to the origin of the oil, and, on refining, these are concentrated in the heavy oil fractions. On gasification, the vanadium compounds are mainly deposited with the oil ash, much of which appears in the catalyst bed and/or the chequers of the gasification plants. These compounds are toxic and precautions are necessary when handling catalyst that has been used for the gasification of heavy oil. The Committee has prepared recommendations which were published in March, 1960 as I.G.E. Safety Recommendation M10 ("Memorandum on Precautions to be Observed in the Handling of Catalysts that have been Used in the Gasification of Heavy Petroleum Fractions"). The memorandum is also reproduced as Supplement IV to this Report.

One of the principal activities of the Committee and one to which it attaches very great importance is the study of conditions and circumstances leading to accidents in gas works. In this connexion, the Committee acknowledges with gratitude the helpful co-operation it receives from all Area Gas Boards, which make available the fullest information concerning accidents at their works. The Committee's main interest is to draw the attention of the industry at large to means whereby a repetition of such accidents may be avoided. Frequently, it seeks to achieve this end by the preparation of recommendations, which become incorporated in the I.G.E. Safety Recommendations. This procedure, however, is not always appropriate and a more suitable method of drawing attention to certain hazards is by means of the brochures entitled "Unusual Incidents at Gas Works, and their Lessons", two collections of which were produced in previous years. A third collection, prepared by the Committee, was published in October, 1959 (*Communication No.* 564).

When the Committee prepared the "Memorandum on Installations for the Use of Light Petroleum Distillates in Low-pressure Gasification Plants" (I.G.E. Safety Recommendation M9; see also Supplement 2, 19th Report of the Chairmen's Technical Committee (*Communication No.* 532)), the delivery of light petroleum distillates to gas works by road tanker was envisaged. There are a number of works where delivery is effected by rail tankers or by ships, and it is accordingly necessary to amend one of the recommendations, which, in its present form, is inappropriate for off-loading from such vessels.

It has been agreed, therefore, to replace the existing subsection (3) of Section 2, which at present reads: "Pumps for

unloading tankers should not be capable of handling gas", by the following:—

> "Pumping installations for unloading light petroleum distillate into storage tanks that are maintained under gas pressure shall be so designed as to avoid pumping air into the tank, particularly when air may be admitted into the receiving tank, either by the couplings of the hoses, or by the action of the self-priming pumps if such have to be used for discharge purposes. In these circumstances, suitable air eliminators should be installed at the outlet of the pumps."

Publication of the Factories Act, 1959, has rendered some of the I.G.E. Safety Recommendations out-of-date in certain details. The Committee is now reviewing all of the recommendations in the light of the requirements of the Act, and the amendments published as Supplements V, VI and VII of this Report are now valid.

The Committee desires to draw attention to the desirability of maintaining the I.G.E. Safety Recommendations in an up-to-date condition. New recommendations as well as amendments to existing recommendations are published from time to time. These are referred to in the Reports of the Chairmen's Technical Committee, and, while the Institution makes every endeavour to ensure that purchasers of the I.G.E. Safety Recommendations are supplied with copies of additions or amendments, it is hoped that holders of the binders will themselves ascertain that any such additions or amendments mentioned in the Reports of the Committee are included in their copies of the binder.

Reference was made in the 20th Report of the Chairmen's Technical Committee (*Communication No.* 554) to the appointment of a small panel to accumulate and exchange information on the hazards associated with the production, storage and use of liquid or gaseous oxygen. This panel has had meetings throughout the year and has had discussions with specialists from the Companies concerned with the production of liquid oxygen. Further meetings are planned for the future, and the panel will report in due course to the Committee.

The Committee has been advised that the Illuminating Engineering Society is revising its Code for Lighting in Buildings and that it has requested advice in connexion with the lighting of buildings in gas works. A small panel has been appointed by the Committee to consider this matter.

Meters Committee

The Meters Committee of the Institution, which is a joint Committee comprising representation of Area Gas Boards and the manufacturers of gas meters, has for its terms of reference the consideration of any technical matter relating to gas meters and the reporting thereon to the Council. It has throughout the year continued to collaborate closely with other Committees concerned with gas meters, including the Technical Committee of the Watson House Centre, and the Meter Section of the Society of British Gas Industries.

The Committee has received with regret the resignation of Mr. P. J. Wilkins (London) from the Meters Committee and from the Sub-Committee on the Standardization of Small-cased Meters, and records its appreciation of his past services.

A good deal of the current work of the Committee is being undertaken by two Sub-Committees dealing respectively with the standardization of dimensions of small-cased meters, and with meter performance with particular reference to the factors responsible for the failure of meters in service. Mr. C. R. Austen (London) is Chairman of the former, and Mr. B. G. H. Clegg, M.A. (Southampton), of the latter.

As was reported in the 20th Report of the Chairmen's Technical Committee (*Communication No.* 554), Mr. Austen's Sub-Committee has the very difficult task of effecting a satisfactory compromise between two conflicting points of view. Small-cased meters are being increasingly used for domestic purposes, and standardization of dimensions should lead to a greater measure of interchangeability of meters on the district and to consequent economies. On the other hand, developments in the design of small-cased meters have been marked during recent years, and it is the opinion of many that the meters now being produced are very much better machines than some of their predecessors. The view of the representatives of the manufacturers is that too great a degree of standardization might prejudice further development and progress. It is hoped, however, that agreement will be reached in regard to the standardization of dimensions between inlet and outlet bosses, and proposals in this connexion are now being studied by the manufacturers. Consideration is also being given to the standardization of small-cased industrial meters, with particular reference to overall height and maximum depth.

In connexion with the work of the Sub-Committee on Meter Performance, questionnaires were circulated to all Area Gas Boards, and, with their co-operation, a good deal of information was collected concerning the reasons why meters were brought in for examination or repair. This information was statistically analysed and an interim report was submitted to the Council, as a result of which a further enquiry, relating specifically to meters that are returned from the district within their period of guarantee, is now being pursued. The Area Gas Boards and the meter manufacturers are collaborating in this project, which, it is hoped, will provide some useful data to the Sub-Committee and assist it materially in its investigations in regard to the behaviour in service and the effective life of gas meters.

Reference was made in the 20th Report of the Chairmen's Technical Committee (*Communication No.* 554) to the consideration which is being given to the overloading of industrial gas meters, having regard to the fact that meters are tested for accuracy with air and the badged capacity relates to air. It was suggested that, in view of the difference between the specific gravities of air and town gas, it should be possible to increase the throughput of a meter when using town gas as compared with air by some 20 per cent without additional loss of pressure. The effect on the mechanical performance of a meter of operating it for long periods at a speed of revolution greater than that at which it was badged is, however, at present unknown. Accordingly, at the request of the Committee, arrangements are being made by a number of Area Gas Boards, in collaboration with the manufacturers, for some tests to be carried out in which two meters, one having a badged capacity of 1,200 cu. ft/hr and the other 1,800 cu. ft/hr are to be installed in series on the district in a gas stream where a prolonged demand of up to 1,800 cu. ft/hr is to be expected. These meters will be kept in operation in the first place for a period of two years, after which they would be subject to examination jointly by the Board and the meter manufacturers concerned. The detailed arrangements for the carrying out of these tests are now being considered by the Committee.

Ad Hoc Committee on Electrical Bonding

Accounts have been given in the last three Reports of the Chairmen's Technical Committee (*Communications Nos.* 511, 532 and 554) of the appointment and work of the *ad hoc* Committee on Electrical Bonding. Prior to the investigation by this Committee, the policy of the Gas Industry and of the electricity industry, as reflected in all the codes of practice, was for the separation of utility services supplying buildings. The work of the *ad hoc* Committee made it abundantly clear that, however desirable such a policy might seem, in practice it appears that its implementation is frequently impossible. Modern building techniques, the increasing use of appliances

using both gas and electricity, and the development of cathodic-protection systems by means of impressed current, have all contributed to difficulties of separation.

After very careful consideration, the *ad hoc* Committee came to the conclusion that it would be safer to adopt a general system of cross-bonding between services rather than to endeavour to maintain segregation of services between which fortuitous connexion may be present. This recommendation was accepted by the Council of the Institution and by The Gas Council, and, at the request of the latter, discussions between representatives of the Institutions of Electrical, of Gas and of Water Engineers were initiated.

The *ad hoc* Committee's report is now being studied by the Technical Committees of the Institutions of Electrical and of Water Engineers.

At the request of The Institution of Electrical Engineers, an informal discussion was recently held between representatives of that Institution and representatives of the *ad hoc* Committee, to clarify certain aspects of the report, from which it was apparent that the electricity industry is not unanimous in its views on the Committee's recommendations. Further evidence of this fact was obtained from the experience of various Area Gas Boards as to the requirements of different Area Electricity Boards in regard to the earthing of appliances using both gas and electricity.

Enquiries are now being made throughout the country by the representatives of both The Institution of Gas Engineers and The Institution of Electrical Engineers as to current practice, and further joint meetings will be held to consider the evidence so accumulated.

Committee on Unaccounted-for Gas

The incidence and control of unaccounted-for gas are matters of considerable concern to the managements of Gas Undertakings and require constant vigilance. The Institution of Gas Engineers has on two occasions issued reports on the subject. In 1938, a Sub-Committee of the Research Executive Committee of the Institution was appointed "to enquire into the possibility of arriving at a formula—sufficiently accurate for practical purposes—to enable Gas Undertakings to reduce to comparable conditions of temperature and pressure gas made as registered by station meters and gas sold as measured by consumers' meters". An Interim Report of this Sub-Committee was published as *Communication No.* 194, and is in the *Transactions* of the Institution, 1938–39, **88**, 534.

In 1950, the Council of the Institution considered that the time had arrived when the advice given in the Interim Report should be implemented particularly in regard to methods whereby the quantity of unaccounted-for gas may be reduced. It accordingly appointed another Sub-Committee, "to revise and enlarge the Interim Report of the Sub-Committee on Unaccounted-for Gas (*Communication No.* 194) for early publication and to include a note of the methods for reducing unaccounted-for gas". The Report of this Sub-Committee was published as *Communication No.* 380 of the Institution and is in the *Transactions* of the Institution, 1951–52, **101**, 36.

In spite of any contribution these Reports may have made, and of the undoubted improvements in technical efficiency in the production, distribution and utilization of gas during the last decade, unaccounted-for gas shows no sign of decreasing. On the contrary, the average for the years 1954 to 1959 for Great Britain as a whole is greater than that for the period 1949 to 1954.

The Council of the Institution accordingly felt it desirable that a re-examination of the subject be made, and for this purpose appointed a Committee on Unaccounted-for Gas, with the following terms of reference:—

> "To study the problem of unaccounted-for gas in all its aspects and to recommend ways of reducing it".

The Membership of the Committee is given on p. 2 of this Report.

The Committee held its first meeting on 3rd December, 1959, and since then has held three further meetings, mainly of an exploratory character.

Ninth Arthur Duckham Research Fellowship

The 20th Report contained a general outline of the proposed studies, by the Ninth Arthur Duckham Research Fellow, on the catalytic cracking of hydrocarbons, and mention was made of an apparatus that had been designed to assist in these studies.

During the past year, the experimental work has been devoted almost exclusively to translating the ideas of the drawing-board into a tangible apparatus that will fulfil the necessary requirements. These requirements include the purification and storage of gases, a technique for forming gaseous mixtures of known composition including tracer quantities of radioactive gases, a catalytic reactor unit through which the gaseous reactants may be passed, a means of analysing quantitatively the gaseous products emerging from the reactor, and, finally, a means of radio-assay of the individual components of the product.

In its present form, the apparatus may be considered in three parts. The first part consists of an all-glass high-vacuum line with the usual gas reservoirs and cold traps. Quantitative transfer of purified gases to an expansion bulb where mixing occurs may be carried out by means of a Töpler pump connected to the working line ; this applies to non-condensable gases. Provision is made for transferring condensable radioactive hydrocarbon gases into the expansion bulb by freezing at liquid-nitrogen temperatures.

Samples of the gaseous mixtures of known composition may be expanded into an evacuated calibrated doser and the pressure may be adjusted to a pre-set value by means of a second Töpler pump.

In the second part of the apparatus, the sample contained in the calibrated doser may be carried in a stream of argon through the hot zone of the catalytic reactor, and the products may then be fed directly into a suitably packed stainless steel chromatographic column where separation of the reaction products occurs, the argon serving as the eluting gas. The individual components of the reaction product then pass in turn through a thermal conductivity cell which is being used in conjunction with a specially built sensitive bridge.

The output from the conductivity bridge is fed into a potentiometer-recorder, and from the trace so obtained a quantitative estimate may be made of each component of the reaction product.

From the conductivity cell, each gaseous component of the reaction product flows in turn through the third part of the apparatus, for radio-assay. Argon-hydrocarbon mixtures are used for the proportional counting of solids containing weak *beta*-emitters, and it is, therefore, estimated that the gases emerging from the conductivity cell will of themselves be suitable for proportional counting if a counter of sufficiently small volume is available. A counter has been designed and built with a capacity of approximately 20 ml. Preliminary experiments at the Isotope School indicated that this counting-head shows considerable promise provided that " end effects " can be eliminated.

Most of the nucleonic instruments necessary for further developing a suitable counter have now been assembled, and

work along these lines will soon be in progress. In the meantime, the other parts of the apparatus are being thoroughly tested and improved where necessary.

Third Dempster Travelling Fellowship

The Third Dempster Travelling Fellowship was awarded, in February, 1960, to Mr. Eric Thornton, B.Sc.(Melb.), M.Sc. (Lond.), Assoc.M.Inst.Gas E. (Deputy to the Officer-in-Charge, Industrial Laboratory, Watson House), to enable a study to be made, in one or more Continental countries, of methods of increasing the utilization efficiency of gas in industrial processes.

It was decided that the programme for the Fellow should be devoted mainly to an investigation of work being carried out in gas industry research and development centres, industrial equipment manufacturers, and various other technological establishments. Particular emphasis was to be given to those projects that relate to research and development work being carried out on industrial gas utilization by the gas industry in this country, such a programme being complementary to that carried out by the Second Dempster Fellow.

On this basis then, and to fit in with the time available, it was decided that the itinerary should include the following centres: Paris, Grenoble, Milan, Zurich, Munich, Stuttgart, Karlsruhe, Darmstadt, Berlin, Hamburg, Essen, The Hague. The tour was carried out in the period from 21st April to 23rd July, 1960, the programme comprising France (2½ weeks), Italy (1 week), Switzerland (1 week), Germany (6 weeks) and Holland (1 week).

A detailed report is being prepared for submission to the Committee, but it is possible to give a number of provisional conclusions based on first impressions:

(1) The principal conclusion was that the major problem in industrial gas utilization is one of price rather than of utilization efficiency. In most places where natural gas was not available, there was the same difficulty in obtaining increased industrial utilization as in this country.

(2) The visits revealed no major applications of gas for which utilization efficiency is markedly superior to practice in Great Britain, nor were there any new applications of industrial gas unfamiliar to the industry in this country. Considerable development work has been carried out on high-temperature radiant tubes, furnaces for scale-free heating, and small recuperators.

It was interesting to find that the establishments concerned with work on industrial gas utilization seemed to be working on practically the same general problems as the Research Stations here, e.g., furnace and burner design, controlled atmospheres, and convective heat transfer from high-velocity burners; differences in approach and particular interests generally result in little overlap.

(3) There are a number of centres, particularly Paris, Essen and Karlsruhe, where research and development work is being carried out that is of considerable importance to industrial gas utilization, e.g., the effects of products of combustion on various materials, design of crucible furnaces, and waste-heat recovery.

Grateful acknowledgment is made to the Continental Gas Associations, Undertakings and firms that so readily assisted the Fellow in his investigations, and to the North Thames Gas Board for granting the Fellow leave of absence.

Institution Gas Research Fellowship

This Fellowship, tenable in the University of Leeds, is at present vacant.

SUPPLEMENT I

REPORT OF THE PANEL APPOINTED BY THE GAS DISTRIBUTION COMMITTEE TO CONSIDER THE EXTERNAL PROTECTION OF STEEL PIPES

Introduction

The interim report of the Panel appointed by the Gas Distribution Committee to consider the External Protection of Steel Pipes was published as Supplement 5 to the 18th Report of the Chairmen's Technical Committee and was presented at the 23rd Autumn Research Meeting in November, 1957. In that report, the results obtained from improvements in the traditional method of coating and wrapping small-diameter service tubing were recorded and it was indicated that a significant advance had been made by the use of double wrapping with glass tissue in place of the current practice of using a single wrap. These improvements were marked and some Area Gas Boards have since decided to employ double wrapping, pending further developments. It was also mentioned in that report that the Panel was collaborating with the manufacturers of coal-tar products with a view to having comparative tests made on bituminous asphaltic wrappings and coal-tar enamels. Since the publication of that report, the Panel has been actively engaged in these investigations.

Comparisons Between Coal-tar, Pitch and Asphalt-based Pipe Coating Materials

Through the good offices of the American Gas Association, the Panel has obtained a considerable amount of information and has also had the views of several American engineers on the relative merits of coal-tar pitch and petroleum bituminous asphalt. It has also received information from European sources, and it is quite clear that there is a division of opinion on this subject. Unfortunately, as is mentioned in a report, from the Coal Tar Research Association, to which reference is made later, a good deal of this information appears to have been commercially inspired and while not necessarily inaccurate is, in the view of the Panel, apt to be biased in the interpretation of experience and of the results of tests made.

Most of the information that the Panel has received from American sources relates to the line-wrapping of large-diameter long-distance pipelines. This method is employed to a large extent in America and the Middle East and has the advantage that damage likely to arise from the transportation and handling of wrapped pipes is eliminated. The opportunities of using this technique in the United Kingdom are rare, and in any case it is not appropriate for the coating of small-diameter service tubing, which represents a considerable mileage in the United Kingdom and is the tubing with which the Panel is primarily concerned.

The Panel has had discussions with the Coal Tar Research Association, the Director of which has kindly made available to the Panel a review of existing literature on the comparison between the two materials. This report is, with the permission of the Director of the Association, printed as an appendix hereto.

The conclusions given therein confirm the views expressed by a number of the American engineers who submitted observations through the American Gas Association.

The advantages claimed for coal-tar are as follows:—

(1) Its water absorption is much lower than that of bituminous materials. Whether, in fact, this is significant in the normal life of a pipe coating is very difficult to ascertain and it is well known that in the United Kingdom, petroleum bitumen has been used as a water-proofing material for many years in many

different ways, such as to resist the action of sea water in tanks and on other port equipment. It is indicated however, that the increased absorption of moisture by bituminous materials may have significance when dealing with cathodically protected installations that are coated with them, since the amount of impressed current that is necessary increases as the moisture absorption increases. The Panel has had an opportunity of studying some figures provided by one of the area Gas Boards in this connexion, but they represent limited experience and, since no direct comparison with similar installations coated with coal-tar enamels is available, it would be imprudent to conclude too much therefrom.

(2) It is pointed out that in certain circumstances bitumen is affected by soil bacteria to a much greater extent than is coal-tar enamel.

One of the characteristics of coal-tar enamel, which is inherent in its constitution, is that, at the temperature of application necessary for the adequate coating of pipes, it emits lachrymatory fumes. These are probably more unpleasant than harmful; nevertheless, they present a difficulty in the factory wrapping of service pipes, which is not experienced when bituminous materials are employed. It is, however, not difficult for adequate ventilation to be applied to the wrapping machinery in a factory, and properly designed plants will overcome this difficulty, some of which have been inspected by the Panel.

Comparative Tests made by the Panel

Manufacturers of steel pipes and suppliers of coal-tar enamels have actively collaborated with the Panel during the last two years in the experimental coating of a number of service pipes with various materials, including:

(i) Bitumen with a single layer of glass tissue.

(ii) Blown filled bitumen with two layers of glass tissue.

(iii) Blown unfilled bitumen with two layers of glass tissue.

(iv) Coal-tar enamel with one layer of glass tissue and an outer wrap of glass tissue, previously impregnated with coal-tar enamel.

(v) Coal-tar enamel with two layers of glass tissue and an outer wrap of crêpe paper.

From tests carried out at the laboratories of manufacturers of steel pipes and individually by members of the Panel, the following observations may be made:—

(i) All pipe coatings incorporating a double wrap proved to be free from "holidays", even after considerable handling.

(ii) No difference between the adherence of petroleum bitumen and coal-tar enamels was observed, and it is probable that any advantage one material might have over the other in this connexion is marginal.

(iii) In the case of coal-tar enamel, the temperature of application is of particular importance. On one occasion when, in order to minimize the effect of lachrymatory fumes, the temperature was kept as low as possible, the adherence of the coating to the pipe was noticed to be poor. If, on the other hand, too high a temperature is employed, coking of the finely divided coal used as a filler is apt to occur. It is not suggested that the temperature of application of bituminous enamels is of no consequence, but there does appear to be rather more latitude in the temperature range available than in the case of coal-tar enamels.

(iv) Whether petroleum bitumen or coal-tar enamel is used, a double coating with a double layer of glass tissue reinforcement produces a markedly superior protection. The reinforcement, which preferably should consist of two separate layers of glass tissue embedded in the coating material, should be so arranged that there is a layer of coating material between the tube and the first glass tissue wrap, and each of the glass tissue wraps should be separated by the protective material. Examples were tested of the use of a single coating with one layer of glass tissue pulled into the material and a second layer being applied as an outer surface wrap. Tests have indicated, however, that a double wrap pulled in is superior to the single wrap with an outer surface wrap. It is suggested that the total thickness of the coating should be not less than $\frac{1}{8}$ in.

(v) It has been established that corrosion can emanate from underneath the millscale on a tube, and that, accordingly, some means of cleaning should be adopted. Probably, the best results are obtained by pickling and phosphate treating. While the treated surface can be covered by a coating of primer, there is the danger of corrosion arising during the period elapsing between the phosphate treating and the subsequent wrapping. Consequently, the wrapping and any internal protection should be carried out without delay. There are, of course, other satisfactory methods of cleaning pipe, for example, by mechanical means or shot-blasting.

(vi) Where coal-tar enamel or bituminous asphalt is used, it is essential to ensure that the appropriate primer for the material in question is employed, since this affects the adherence of the enamel to the pipe. The time of curing of the primer should be in accordance with the recommendations of the suppliers of the materials.

The importance of the careful application of the coating cannot be over-stressed. It is desirable that wrapping be executed in accordance with a specification, the terms of which should be agreed between the purchaser, the supplier of the wrapping material and/or the organization carrying out the wrapping. The Panel is giving further consideration to the question of wrapping technique and hopes to prepare recommendations in this connexion in the near future.

Other Materials Examined by the Panel

(i) The Panel has examined another pipe wrapping which has the appearance of a pliable roofing felt and which is applied to the pipe as a tape after priming the pipe with a coal-tar emulsion primer. This material appears to have very good properties so far as freedom from "holidays" is concerned. The wrapping becomes very soft with handling, however, and it is then extremely difficult to apply to a pipe, without forming creases and voids. The time of application for double wrapping with this material is lengthy and some difficulty was experienced in obtaining good adhesion of the material to the pipe.

(ii) The Panel has also seen an interesting development in the use of a petroleum grease wrapping with an additional coating of crêpe paper, which improves its handling. Some members of the Panel felt, however, that, if an additional wrap is to be applied, it should have insulating and corrosion-resisting properties, in order to obtain the best possible value from the additional cost involved, and this is not the case in respect of crêpe paper.

(iii) The Panel has also taken account of recent developments in tapes of polyvinyl chloride. These appear to have some merit for pipe protection, but are rather expensive for general use. An American source has expressed the view that these tapes are only water-repellent for a short period of time and that the adhesives used provide an ideal nutrient for bacteria. It has also been found that with some of these tapes the adhesion decreases during the course of time. Furthermore, the original elasticity of the tape, which is an advantage during wrapping, enabling a reasonable degree of tension to be employed, thus ensuring close contact to the pipe, tends to decrease during the course of time. This, coupled with loss of adhesion, causes the wrapping to become slack.

(iv) Recently, the Panel has seen an experimental sample of steel tube surrounded by a plastic tube, which may prove a suitable alternative to other forms of wrapping.

Conclusions

(i) The fundamental requirements for the adequate protection of steel pipe that have become apparent to the Panel during the course of its investigations may be summarized as follows:—

(*a*) The protection must be such as will enable a protected pipe to be installed in such a manner as to ensure that, when the ground is filled in, the wrapping remains intact, that is to say, free from "holidays".

(*b*) The protection should be mechanically strong, so as to resist penetration by stones and similar materials during backfilling, and also to withstand the subsequent pressure of the earth above the pipe.

(*c*) During the lifetime of the pipe the high dielectric strength of the coating should be maintained and be unaffected by any corrosive properties which may be present in the surrounding soil, and should be especially resistant to the absorption of moisture, which is an essential factor in corrosion.

(ii) Whether bituminous asphalt or coal-tar enamel is used for the factory wrapping of service pipes, double wrapping is desirable, the preference being for two wraps pulled into the material as distinct from an inner wrap and an outer surface wrap. When the former method is carried out in accordance with the makers' specifications, the difference between coal-tar and bitumen, as shown by laboratory tests, appears to be marginal.

(iii) The technique of applying protective coatings is of paramount importance. Quite apart from the suitability of the materials, including the appropriate primer, a protective coating can be rendered ineffective by faulty application.

Acknowledgments

The Panel wishes to acknowledge the assistance it has received from the following:—American Gas Association; Coal Tar Research Association; E. Hardman and Company Limited; Metrotect Limited; Stewarts and Lloyds Limited; Wailes Dove and Bitumastic Company Limited; Wellington Tube Works Limited; and Winn and Coales Limited.

APPENDIX 1

A Comparison Between Coal Tar Pitch and Asphalt-based Pipe-coating Enamels

A LITERATURE SURVEY

BY D. McNEIL

C.T.R.A. Report No. 0238. Category B

Introduction

Any attempt to provide a critical comparison of the advantages and disadvantages of coal tar pitch pipe-coating enamels and asphalt pipe-coating enamels by a study of the relevant literature meet two initial difficulties.

The first difficulty lies in the question of nomenclature. In many papers describing the performance of bituminous anti-corrosion coatings it is not easy—in some cases it is impossible—to determine the exact formulation of the materials used. The terms "bituminous coatings" or "bituminous enamels" include any protective coating based on coal tar pitch, bitumen or natural asphalt. "Coal tar enamels", "plasticized pitch enamels", "coal tar-based coatings", "special pitches", *etc.*, refer to pipe-coating enamels prepared by the addition of a filler such as talc to a coal tar pitch plasticized by the dispersion in it of finely divided coal. The competing materials are referred to as "bitumen enamels" or "asphalt enamels", "asphaltic coatings", "asphaltic bitumens" and so on. Such materials consist of bitumen (the residue left on the distillation of crude petroleum) which has been (usually) partly polymerized by air blowing and modified by the addition of a mineral filler.

The second difficulty is that many of the articles, particularly those in American publications, tend to have a propagandist bias. Protagonists of coatings based on bitumen seek to emphasize the advantages of such materials, but omit references to their defects. Similarly advocates of coal tar coatings make claims, unsupported by any quantitative evidence, for the superiority of these types of coating. The next section gives a selection of these generalized claims.

General Views on the Performance of Bituminous Coatings

According to Boyd[1], coal tar enamels are superior to other types of coating. When properly coated, with the help of cathodic protection if necessary, a pipe should never corrode. On the other hand, Kühr *et al*[2] state that, although coal tar-filled enamels and asphaltic bitumens are used in the field, blown filled bitumen shows advantages when properly applied and, for mill-coated pipes, blown bitumens are decidedly to be preferred.

Kelly[3] states that in recent years 95 per cent of steel pipes laid in the U.S. have been protected by coal tar-based coatings, the high resistance of which to corrosion is due to their resistance to water absorption, their high dielectric value (this reduces the current required for cathodic protection) and their good bond to steel or coal tar primers. These advantages of good dielectric properties, low moisture permeability, resistance to bacteria, chemicals and petroleum products, are also stressed by James[4], who, also, however, touches on two of the disadvantages of talc-filled, coal-plasticized, coal tar pitch enamels. These disadvantages are the tendency to cold flow and the hazards involved in their hot application. Asphaltic coatings are more flexible than coal tar-based coatings, but absorb moisture and tend to lose their "bond" to the pipe. This lack of flexibility of coal tar coatings is also referred to by Ewing[5] and Burnett[6]. The latter states that coal tar enamels have an excellent record as pipe-coating materials, but some improvement is required in their resistance to cold without causing sagging. Thomas makes the point that to be effective bituminous coatings must be applied to a reasonable

thickness—between $\frac{1}{16}$ in. and $\frac{1}{4}$ in. Coal tar coatings are more stable and waterproof, but they tend to flow when warm and crack when cold. These tendencies are less marked with asphaltic coatings. This question of moisture absorption is, according to Thomas[9], most important. Hard pitch is the most resistant to penetration by moisture and there is a transition in moisture permeability from very low for hard pitch to very high for Trinidad asphalt. Although coatings of both tar enamel and asphalt greatly reduce the current required for adequate cathodic protection, the preferred coating materials to use in addition to cathodic protection are, because of their low moisture pick up, hot-applied coal tar enamels.[9] Fully plasticized coal tar enamels satisfy the three criteria for a satisfactory coating—good electrical resistance, imperviousness to moisture and uniform thickness of application—and have a service range of −20°C to +160°F.[9]

According to other authors, the better resistance of coal tar-based products is not of much practical significance, and filled bitumen or asphalt enamels, except for their solubility in petroleum products, are fully competitive.[10] The amount of moisture which can penetrate or permeate such coatings is insufficient to support significant corrosion since they are much less permeable to oxygen and other gases than they are to water.[11] Although coal tar enamels are to be preferred in oil-soaked ground, they are more brittle than coatings based on bitumen and there is little difference in the adhesion of either type of coating.[12]

There are very few direct comparisons of the performance of coal tar enamels and bitumen-based enamels in actual service. Hayes[13] states that in one location asphalt-coated pipes had to be removed after nine years, but pipes coated with coal tar enamel were in perfect condition after six years.

Almost all the views and statements given above are derived from American publications. In Holland and Belgium, filled blown bitumen is the preferred pipe-coating material. In France, plasticized coal tar enamels are used to a considerable extent although, on balance, the asphalt-type coatings are the more popular. Plasticized coal tar pitch is being considered in Holland; trouble is encountered there due to the penetration of bitumen coatings by reed roots under anaerobic conditions.[14]

In Germany, special plasticized, filled coal tar pitch compositions are being increasingly used. They may either be cold-applied by cutting back with special solvents, or, more usually, applied hot. The pipes are usually coated before leaving the factory, and are covered with a protective wrapper. These materials were used for coating the Lippstadt-Wiedenbrück gas pipeline and have proved as satisfactory as bitumen-based coatings. They have also been used to coat several hundreds of tons of spun iron pipe laid in the corrosive soil of the Weser marshes.[15]

Discounting as far as possible the bias of many of the views and statements summarized in this section, the advantages and disadvantages of the two competing pipe-coating materials —plasticized, filled coal tar enamel and filled blown bitumen enamel, each used with its appropriate primer—may be summarized thus:

Coal tar enamels have, it is claimed the advantages of:

(i) lower moisture absorption, which is particularly important when anti-corrosion measures include cathodic protection;

(ii) better adhesion;

(iii) resistance to bacterial attack and attack by plant rootlets;

(iv) resistance to solution by petroleum products;

(v) resistance to attack by common chemicals.

They are said to have the disadvantages of:

(i) tendency to flow at high temperature and to brittle fracture at low temperature;

(ii) they are less "flexible";

(iii) they are unpleasant to apply, particularly in the factory, due to lachrymatory fumes they evolve when heated.

The next sections of this memorandum attempt to examine critically the meagre literature evidence for the statements made in the last two paragraphs.

Moisture Absorption of Pipe-coating Enamels

Moisture-absorption tests on bituminous pipe-coating materials have been carried out in a number of different ways. Probably the first such tests were those carried out by Wrestler and Corfield[16] about 1930. The technique used for these tests was to coat thin copper plates, 2 in. square, with the protective materials so that after drying the coating was $\frac{1}{4}$ in. thick. The plates were weighed before and after coating, to obtain the net weight of coating material, and then immersed in distilled water. The plates were periodically removed from the water, the surface water dried off by placing for 15 min. in a $CaCl_2$ desiccator, and the plates re-weighed to give the percentage moisture absorption. All tests were done in duplicate.

The results of these tests, expressed tabularly, were:—

Code No.	Nature and Softening-point of Enamel	Moisture Absorption—gm/sq. ft. of surface after immersion for :			
		100 days	200 days	400 days	1,000 days
1	2	3	4	5	6
24	Asphalt, s.p. 155°F	2·5	3·5	5·5	8·0
25	Asphalt, s.p. 165°F	3·0	4·5	6·25	9·25
47	Coal Tar, s.p. 173°F	0·3	0·6	0·9	—
48	Coal Tar, s.p. 200°F	0·1	0·2	0·4	—
49	Coal Tar, s.p. 180°F	0·5	0·8	1·3	—
69	Coal Tar, s.p. 179°F	0·6	0·9	1·2	—

The results of tests carried out by H. A. Price, and extending for a number of years, have been reported by McComb.[17] In these tests, 1-in. cubes of the bituminous material were weighed and immersed in closed jars of tap water. At frequent intervals, the cubes were removed, wiped dry and re-weighed. The weight of water absorbed by the 1 in. cubes plotted against time (in years) is shown in Figure 1. Other tests, by W. H. Price, are reported in the same source. In these, circular brass discs 2½ in. diameter by $\frac{1}{16}$ in. thick were first of all cleaned, then dip-coated with the bituminous coating. The coated discs were cooled, weighed and allowed to stand overnight and then suspended from glass hooks in closed jars of tap water. At intervals, the specimens were removed, surface moisture removed by air-blowing and the samples re-weighed. The results are shown graphically in Figure 2.

Hayes[13] describes tests in which the moisture absorption of coal tar enamel, unfilled asphalt and filled asphalt is compared. In 100 days immersion, the weights of moisture absorbed by 1 sq. ft of surface were 0·2 g for coal tar enamel, 2·1 g for unfilled asphalt and 6·4 g for asphalt enamel.

Other results showing the same kind of behaviour have been described by Fair[18] and have been obtained in moisture absorption tests carried out in C.T.R.A. laboratories. These tests were of relatively short duration; an oblong plaque of the material under test was immersed in a stream of slowly flowing tap water and surface dried and re-weighed at intervals.

The coal tar enamel quickly came to an equilibrium moisture content. 0·29 per cent of moisture was absorbed in the first 24 hr, and after 16 days' immersion the moisture content was 0·31 per cent. The vermiculite-filled bitumen enamel

absorbed 0·98 per cent of water during the first 24 hr, and this value increased in a regular manner until after 16 days the moisture content of the bitumen enamel was 1·6 per cent.

The mass of evidence, therefore, leaves no doubt that pipe-coating enamels based on coal tar pitch are very resistant to water permeation and that even after years of exposure the amount of moisture absorbed is less than 1 per cent by weight. In contrast, enamels of similar softening-point and penetration produced from bitumen or asphalt slowly absorb water, the amount taken up progressively increasing with time without reaching any maximum.

The important point, however, is whether the absorption of moisture by the bitumen-based coatings causes their electrical resistance to decline to such a low value and sufficiently rapidly that corrosion can occur, or, alternatively, that the current requirements for adequate cathodic protection become economically prohibitive. The evidence for or against this is meagre and inconclusive.

Romanoff[19], summarizing the results of the very extensive series of tests carried out by the U.S. National Bureau of Standards in conjunction with the American Petroleum Institute states:

> "The data on the conductance of the coatings lack uniformity because frequently one section of a coating showed many times the conductance of another section of the same coating at the same test site. Based on the data available, it is difficult or impossible to determine whether this lack of consistency is the result of lack of uniformity in the thickness or composition of the coatings, poor application, or non-uniform soil conditions. The important fact is that the amount of protection afforded by many coatings was not uniform even under comparable conditions. . . . It was impossible to determine positively the relative merits of coal tar and asphalt as protective coatings."

Glander[20] gives in graphical form the values for the change of electrical resistance of bitumen and plasticized coal tar compositions when in contact with water or damp soil. For bitumen, the value falls from an initial figure of 10^9 ohms/sq. cm to under 10^4 ohms/sq. cm after 20 days and thereafter remains constant. The plasticized coal tar enamel has an

May, 1956. Los Angeles Department of Water and Power.

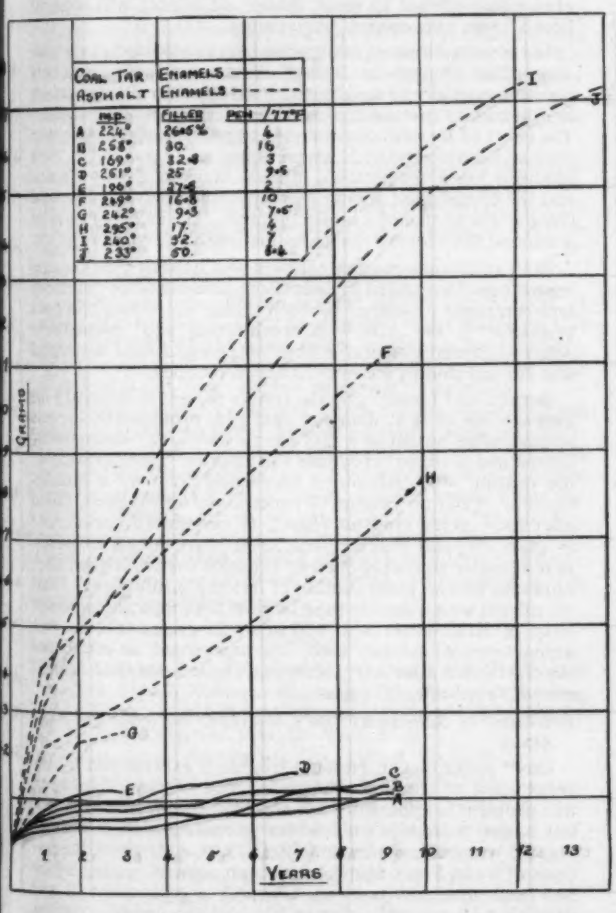

FIGURE 1.—*Water Absorptive Properties of Coal Tar Enamel and Asphalt Enamel.*

June, 1956. U.S. Department of The Interior Bureau of Reclamation.

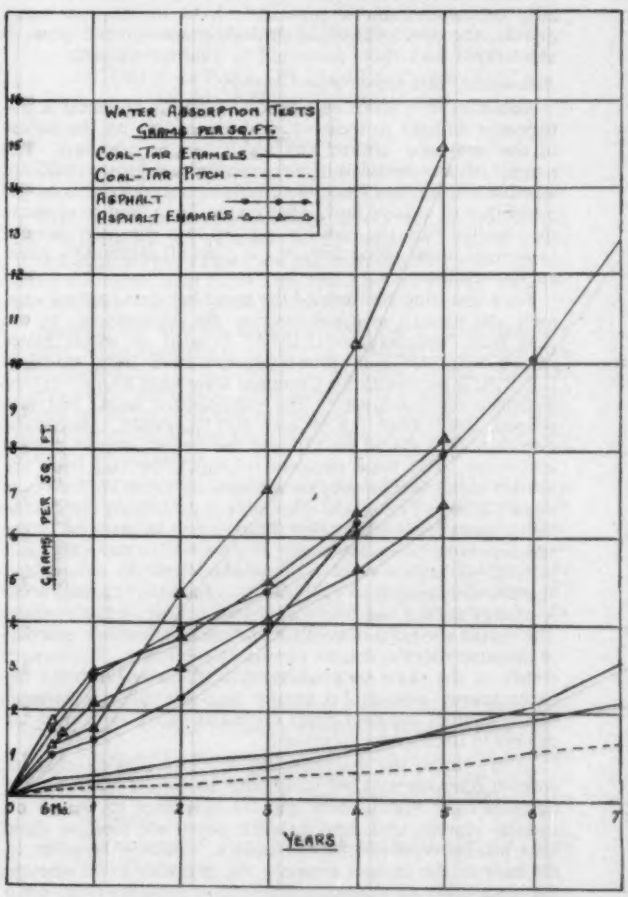

FIGURE 2.—*Results of both Filled and Unfilled Materials that were included in 1949-56 Tests.*

initial resistance of between 1 and 2 × 10^8 and this drops to 10^6 after about 60 days.

Perhaps the most useful comparison is that given by Sharpe[21] in his paper entitled "Economic Considerations in Pipeline Corrosion Control" to the Tenth Annual Conference of the National Association of Corrosion Engineers, held in Kansas City, in March, 1954. In this paper, he details the cost of protecting two sections of the Hearne-Irving Products Pipeline of the Humble Oil Company. One section was protected with coal tar enamel reinforced with fibre glass and felt wrappings and cathodically protected by rectifiers. The second section, laid in similar soil, was protected with asphalt enamel with glass and felt wrapper and also cathodically protected. The current drain on the coal tar-protected section averaged 0·034 amps/mile and the operating costs 1 to 2 dollars/mile/year. The asphalt-coated section showed a current drain of 1·2 amps/mile, and the operating cost of cathodic protection ran out at 8·7 dollars/mile/year.

Thus, although the evidence is scanty, it does indicate that asphalt or bitumen pipeline coatings, due to their high moisture permeability, decrease in electrical resistance and when used in conjunction with cathodic protection markedly increase the current required. There is, however, no clear-cut evidence that, in the absence of cathodic protection, particularly on small-diameter pipes free from holidays or other defects, the deterioration of asphalt enamel-coated pipes is more rapid than those protected by coal tar enamels.

Adhesion of Bituminous Pipe Coatings

Adhesion of a paint or protective coating to metal is notoriously difficult to measure, and, depending on the nature of the test used, almost any result can be obtained. The nature of the metal surface, whether rough or smooth, whether the implied force is sufficiently rapid to obviate the possibility of viscous flow, whether the force used to separate the coating from the metal is applied in a direction parallel or normal to the metal surface, *etc.*, can all profoundly affect any comparison.

Tests assessing strength of the bond between coal tar enamels and asphalt enamels meeting the requirements of the A.W.W.A. specification C.203/57 bonded to metal plates coated with the appropriate primers have been made at C.T.R.A. laboratories by a method somewhat similar to that described by Goldman.[22] The sand-blasted metal was first primed, and, after the primer had hardened, aluminium cylinders were placed on top and the molten enamel poured into them. The force required to knock the cup from the primed metal surface was then measured using an Izod-type impact tester. The results showed a wide scatter, but, statistically interpreted, showed no difference in the strength of the adhesive bond in the two cases. It is probably true to say that, provided a proper bond is established between primer and enamel, the strength of the metal-to-bituminous coating bond is always greater than the cohesive strength of the coating. The tensile strengths of coal tar enamels and bitumen enamels of the same viscosity are not significantly different. Goldman[23] comes to the same conclusion, that the adhesive bond between enamel and steel is greater than the cohesive strength of the enamel for steel pipes coated at 325°F with coal tar enamel in the absence of primer.

In any case, the specifications for pipe-coating enamels contain rigorous tests for initial and developed adhesion, for freedom from viscous flow and for resistance to shatter on sudden impact, and, undoubtedly, materials meeting these tests will prove satisfactory in service. There is, however, in the case of the asphalt enamels, the question as to whether the absorption of moisture will eventually destroy the bond between the metal and the coating. Romanoff[19] states that "those bituminous coatings which absorb small quantities of water generally retain their original strength; whereas those which absorb appreciable quantities of water may become spongy or may crack or wrinkle causing the material to lose its protective qualities." On this question of adhesion, claimed as one of the advantages of coal tar pitch enamels over bitumen or asphaltic materials, one must conclude that there is no evidence to justify such a claim. As a class, the adhesion of bituminous pipe coatings is extremely good.

Resistance to Cracking by Soil Stresses. "Flexibility"

The better flexibility of bitumen pipe coatings is frequently claimed as an advantage when such materials are compared with similar products based on coal tar pitch. There is, however, no concrete evidence for this claim, which appears to be based on a comparison of bitumen or asphalt and unfilled, unplasticized coal tar pitch of the same softening-point.

It is, of course, well known that the increase in viscosity with reduction in temperature of coal tar pitch is much greater than in the case of bitumen. From some points of view, this is an advantage, but from others it is a drawback. A pitch which is sufficiently hard not to flow or sag at a high temperature will have a much higher viscosity and, therefore, be much more brittle at low temperatures than a corresponding grade of straight-run or cut-back bitumen. Conversely, a straight-run pitch which is of a sufficiently low viscosity at low atmospheric temperature to resist shatter on impact will tend to flow at high atmospheric temperature.

We are not, however, comparing here unmodified pitch with unmodified bitumen or asphalt. Pitch pipe-coating enamels consist essentially of coal tar pitch modified by the dispersion in it of certain types of coal and the addition of mineral filler. The effect of the coal dispersion is to reduce substantially the change in viscosity with temperature, so that a pitch thus modified has a temperature interval between the flow-point and the brittle-point greater than an unmodified bitumen and comparable to that of a blown bitumen. The incorporation of a mineral filler further increases the impact strength of pitch.

Both pitch pipe-coating enamels and asphalt pipe-coating enamels are formulated to meet the requirements for flexibility and resistance to shatter by both direct and indirect impact embodied in the A.W.W.A specification and, particularly when reinforced by durable fibre wrapping, should withstand any stresses due to soil movement in practice.

Burnett and Lewis[24] give the results of tests in which 18 in. long sections of 3½ in. diameter steel pipes protected by various systems were buried in a clay slurry which was alternatively wetted and dried to reproduce soil stresses. Deterioration of the coating was determined after each cycle by a holiday detector. Coal tar enamel (8 penetration) unwrapped, failed after four cycles, coal tar enamel (7 penetration) reinforced by glass fibre and wrapped with Kraft paper passed 25 cycles, as did similar enamel applied as a double coat with glass fibre sandwich and an outer coating of felt and Kraft paper. Coal tar enamel with a double wrap of glass fibre tape and an outer wrap of Kraft paper also withstood 25 cycles. Of the two asphalt enamel systems used, the unwrapped un-reinforced material failed after four cycles and the felt-wrapped asphalt enamel failed after 20 cycles.

Resistance of Bituminous Pipe Coatings to Bacterial and Plant Attack

Day[14] states that in Holland trouble is experienced by the penetration of bitumen enamels by reed rootlets. However, this problem is apparently not confined to bitumen enamels, but is also present when coal tar enamels are used with an organic wrapping. Romanoff (Ref. 19, p. 132) gives illustrations of a plant root found beneath an asphalt coating which had been protected by tarred felt, and of grass roots in and beneath a 10-year-old asbestos-felt coal tar enamel coating.

On the question of immunity from bacterial attack, the evidence is rather fuller. Burgess[25] notes that partial oxidation

of asphalt and its fractions is obtained when these are submitted to laboratory exposure to soil micro-organisms.

Kulman[26] tested the nutrient inertness to fungi and the fungistatic activity of both coal tar enamels and asphalt mastic coating. All coatings were inert unless used in conjunction with cotton wrapping fabric; none was completely fungistatic. Pipes coated with coal tar enamel and asphalt mastic were exposed to soils of various types and after seven years the coatings were tested for their insulation resistance and inspected for fungal and bacterial growth. In a corrosive soil with aggressive fungi, all the asphalt mastic-coated pipes had 90 to 99 per cent decrease in insulation properties, whereas none of the coal-tar-protected specimens showed a similar reduction. The asphalt mastic decreased in resistance quickly, and bacterial and fungal colonies were found growing on it. It also softened. Coal tar enamel itself was found to be immune to attack although when used with an asbestos-felt wrapping some decrease in insulation resistance did occur.

Effect of Solvents and Industrial Chemicals on Pipe-coating Enamels

It would be expected that solvents of similar chemical types to bituminous enamels would soften and eventually dissolve them. Asphalt enamels, being of petroleum origin, are softened by petrol, gas oil, kerosine and other petroleum distillate oils, whereas such solvents have comparatively little effect on coal tar enamels. The latter are, naturally, softened by aromatic solvents such as benzene and toluene and by more polar solvents like carbon disulphide, chloroform, pyridine, *etc.* These more powerful solvents have, however, an even greater effect on the asphalt enamels.

Little has been published about the resistance of bituminous coatings to dilute acids, alkalis or salt solutions, but such information as is available suggests that both coal tar enamels and bitumen enamels are satisfactorily resistant to such reagents.

Application Hazards of Coal Tar Enamels

Pipe-coating enamels are applied to the primed pipe at about 240° to 250°C. Coal tar enamels when heated to this point give off copious white fumes, which are lachrymatory. Bitumen enamels, under the same conditions, fume only slightly and the fumes are not particularly unpleasant.

The emission of these fumes, which mainly consist of small amounts of sublimable polynuclear aromatic compounds, from coal tar enamels, cannot be prevented, but any hazardous effect on workmen can be avoided by installation of adequate ventilation and fume extraction in enclosed spaces where hot coal tar enamels are to be employed and by operating to windward of the pipe in outdoor locations. The fumes are more unpleasant than harmful although workmen with sensitive skins may suffer some erythema, particularly in hot weather or near the sea coast.

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SUPPLEMENT II

INTERIM REPORT ON PLASTIC PIPES FOR GAS DISTRIBUTION PURPOSES

(1) Introduction

The corrosion of underground pipes, especially those of small diameters, is a serious problem in gas distribution.

It is well known and has been amply demonstrated that plastic materials are generally highly resistant to most forms of chemical attack, so that when it became possible to produce small-diameter tubes from such materials on a large scale the gas industry was extremely interested.

Ignoring for the moment the question of cost, the first aspect to be considered is that of mechanical strength. In this connexion, it has been demonstrated that, with the reservations mentioned later, plastic pipes which appear to afford sufficient mechanical strength for the particular duty called for in the laying and installation of a gas service pipe can be manufactured.

The second aspect relates to the susceptibility of the plastic materials at present available to attack by hydrocarbon oils and the aromatic hydrocarbon gases present in most manufactured gases. The chance of external damage to the pipes from this cause is slight, since in normal circumstances underground soils are unlikely to contain hydrocarbon oil, but the possibility of internal attack from aromatic hydrocarbon gases is a more serious matter.

(2) Requirements

If plastic pipes are to be used for gas distribution purposes, they should be able to satisfy the following requirements:—

(*a*) Have sufficient rigidity to be able to remain circular throughout their serviceable life, i.e., they must be able to withstand the superimposed loading of the sub-soil.

(*b*) Be reasonably rigid on a longitudinal axis, i.e., they should not sag.

(*c*) Be resistant to chemical attack by constituents present or likely to be present in the gas to be distributed.

(*d*) Be capable of withstanding internal pressure with an economical wall thickness.

(*e*) Be impermeable to liquids and gases.

(*f*) Be capable of being joined together to form a leak-proof joint.

(*g*) Be capable of being joined to a metal to form a leak-proof joint.

(*h*) Maintain the above-mentioned characteristics without becoming unduly brittle throughout the temperature range normally encountered during the storage and use of service pipes.

(3) Availability of Supplies

Among the materials from which plastic pipes are manufactured are the following:—

Polyvinyl chloride (P.V.C.), both plasticized and unplasticized; polyethylene or polythene, cellulose acetate, cellulose acetate butyrate, glass fibre reinforced with various resins including epoxy resins, polyesters, silicones and furane.

(4) Progress in the Gas Industry To-date

During the last few years, a number of Area Gas Boards have carried out tests on plastic materials. No tests of longer than five years duration have been possible under normal conditions, but various accelerated tests of a chemical character have been made in which plastic pipes have been subjected to contact with concentrations of the types of hydrocarbons likely to be encountered in town gas. In almost all cases, hydrocarbon attack has been observed with, in some cases, swelling of the plastic materials. One Area Board carried out tests in different parts of its area and found that the attack varied according to the nature and composition of the gas.

Reports have been received from various sources, notably the United States of America and Holland, of the successful use of plastic pipes for the distribution of natural gas. This gas is, however, singularly free from aromatic hydrocarbons, and, while the length of plastic pipe so far installed for this purpose might be regarded as impressive, *per se*, it is small in relation to the total usage of pipes. In this connexion, it is of interest to quote from page 54 of the *American Gas Journal* dated 15th August, 1959:—

> "The A.G.A. Sub-Committee has recommended four types of plastic materials for use in the distribution of natural gas. None of the four are recommended for gas containing aromatic hydrocarbons, which generally excludes their use for distribution of manufactured gas."

It has been suggested that it might be possible to employ plastic pipes for gas distribution in limited areas in Great Britain where the aromatic hydrocarbon content of gas distributed is sufficiently low and unlikely to present any serious problem. Objection has, however, been made to such a proposal on the ground that, with the present state of the development of gas manufacturing processes and the rapid extension of gas distribution grids, perhaps on a national scale, it would be imprudent to predict that such areas would always be supplied with gases having low aromatic hydrocarbon contents.

(5) The Future Outlook

It is regrettable that some manufacturers of plastic pipes, realizing their potentialities in many phases of engineering work, have been inclined to press their products on the gas industry without paying sufficient heed to the limitations imposed on their use by the above-mentioned considerations. In certain cases, claims have been made for plastic pipes that have subsequently been withdrawn, and this has tended to create a sense of apprehension in the gas industry.

It would seem, from the rather indistinct picture that has gradually emerged during the last decade, that at the present time pipes manufactured from polyvinyl chloride are likely to be the most satisfactory for the gas industry. There are two types: (*a*) the high-impact, plasticized or modified type, and (*b*) the unplasticized type known as rigid P.V.C. The latter has not the same strength as modified P.V.C., but it is considered that it is sufficiently strong for the duties required of it in gas distribution, and, moreover, has the advantage of being more resistant to attack by aromatic hydrocarbons.

(6) Comments on Problems Arising from the Use of Plastic Pipes

(*a*) There may be limitations on the use of plastic pipes for the conveyance of gas inside buildings, and, in consequence, some kind of joint between a plastic pipe and a metal pipe might be required underground. A flexible connector may be used for this purpose, and there are also numerous types of compressing joints that may be suitable.

(*b*) The phenomenon of "cold flow" whereby solid materials are apt to flow under the influence of pressure is characteristic of plastic materials, and it may be found that screwed joints or joints of the compression type may tend to slacken off after several months. In many engineering applications of plastic pipes, this might not be of real significance, but even a very small leakage of gas underground must be regarded as a serious matter. There are methods of mitigating the problem of jointing, such as, for example, the use of an internal metallic sleeve in conjunction with a compression joint.

(*c*) A gas service pipe, once installed, ought to be satisfactory for at least 50 years, but there is as yet insufficient conclusive evidence that the material will remain stable for such a period. Further, the pipe should retain its original shape, i.e., circular throughout its working life. A further phenomenon, known as "cold creep stress", appears to affect plastics. This aspect has been thoroughly considered in the journal *Plastics*, of April, 1959, which contains reports by a number of West German Companies on the testing of plastic pipes. It has been concluded from these reports that "it is well known and a thoroughly investigated fact, that all thermo-plastics will creep under load to a more-or-less considerable extent in certain temperature ranges. This is in principle true both of steel, at temperatures of 500°C and more, and of thermoplastic materials at normal temperatures, and within stress ranges which are far removed from the yield-point. Therefore, it is no longer possible to characterize the physical properties of thermo-plastics (which are also called visco-elastic materials) for the reasons outlined above—by indicating the tensile, or ultimate strength, or yield-points, nor by stating moduli of elasticity and similar coefficients. All characterizations should include the time factor in some way or other".

The results of the above mentioned tests demonstrated that the strength deteriorates rapidly during an initial period, the rate of decrease in strength depending on the temperature. After the initial rapid deterioration in strength, the rate of further decrease is considerably slower. Graphs are given in the above mentioned report showing that initial strength may be decreased by approximately 50 per cent in less than 10,000 hr. Extrapolation of these graphs for periods up to 50 years indicate that, even with this deterioration, pipes of sufficient strength may be produced,

providing appropriate design factors are employed. Thus, for example, the initial strength of a rigid P.V.C. material of 6,500 lb/sq. in. would be reduced to 2,000 lb/sq. in. in 50 years at a temperature of 20°C. This temperature is higher than that normally to be expected underground, and this depreciation in strength should not necessarily be a source of alarm. It has significance in determining the ultimate strength of the material, with which is associated the ability of the pipe to maintain its original shape, i.e., circular. Already, the Gas Distribution Committee has received information of the flattening of plastic pipes under continual loading for many months. Clearly, the thickness of the pipe wall is a dominating factor in the selection of a pipe to give a serviceable life of 50 years and over.

(*d*) An unknown factor that may affect the strength and properties of a plastic pipe buried below ground for some years is that of moisture absorption, for it is known that some P.V.C. materials do absorb moisture.

(*e*) With regard to permeability, the Committee has no positive evidence that plastic pipes are impermeable to gas, but the water industry has had experience with pipes made of certain types of plastic materials, notably polythene, of contamination of water supplies arising from leaking sewage or town gas in the medium surrounding the pipes.

(*f*) There appears to be no difficulty in joining up plastic pipes, the cemented joint, properly made, being quite satisfactory in its simplest form. The joint is made by pushing plain ends of the pipes into a socket, the male ends having been painted with a suitable solution. Whether the making of such joints would be entirely satisfactory during normal service laying operations is a matter for study, but there does not appear to be any good reason for supposing otherwise.

(7) Conclusions

The use of plastic pipes as gas service pipes is very attractive. The expense of laying and subsequent exhumation of service pipes, however, is such that the gas distributing engineer needs to be well satisfied that no defects will arise during a serviceable life of at least 50 years. Subject to the provision of such satisfaction and to the initial cost of the material and laying differing little from those of a protected steel pipe, there is no doubt that the use of plastic pipes can make a substantial contribution to the advancement of the gas industry.

The manufacturers of plastic materials, it is believed, are aware of the gas industry's problems and are endeavouring to find solutions. Many gas engineers are confident that in due course the problems will be solved and that, ultimately, plastic pipes will replace steel, but until they are absolutely assured that the material will be at least as reliable as steel they are hesitant to go ahead.

Addendum

Use of Steel Tubes Protected by Plastic Materials

Experiments have been carried out on the encasement of steel service pipes with a plastic sheath made of P.V.C. or polythene. Providing the process is economical, this would appear to afford a reasonable solution to the problem, but two difficulties that have emerged from these experiments are concerned with the adhesion of the plastic material to the steel pipe and the vulnerability to foreign bodies (stones, etc.) having sharp edges of a comparatively thin coat of plastic materials. A further long-term consideration is that of the ability of the plastic material to retain its properties when laid underground for many years. If, for example, the initial elasticity of the plastic sheathing is affected, there may be a tendency for it to separate from the steel.

Another interesting development is the coating of a steel pipe with a rubberized coal tar encased in a plastic sheathing. This combination is being produced in America, and it is understood the British steel pipe manufacturers have details of the process.

SUPPLEMENT III

SAFE ACCESS TO BUNKERS AND HOPPERS

(1) In the following recommendations, the term "bunker" is used to cover all types of bunkers and hoppers, including those on moving machines, which are large enough for a man to enter.

(2) Entry into bunkers containing coal, coke, coke breeze or other materials of a similar nature can give rise to serious hazards. These hazards can take any of the following forms:—

- (*a*) Injury or suffocation due to material being allowed to flow into a bunker whilst men are working in it;
- (*b*) similar injury due to collapse of the material, either by the sudden release of a blockage or by the deliberate running out of the contents;
- (*c*) gassing from either carbon monoxide or sulphur dioxide given off from adjacent processes, or, in the case of fire-fighting operations, by gas or fumes given off either by the fire-extinguishing apparatus or by the fire itself.

(3) Entry into such bunkers without a permit issued by an authorized person should, therefore, be prohibited. Such permits should be issued only when the authorized person has assured himself that it is safe for persons to enter the bunker or to carry out operations from above the bunker when dangerous conditions exist. Consideration should be given to the following precautions in connexion with hazards that may be encountered:—

- (*a*) Conveyors, hoists, screens or similar machines should be immobilized, where practicable, by the authorized person to avoid the danger of conveying materials into the bunker when men are inside;
- (*b*) on account of the inherent gassing risk, suitable breathing apparatus, preferably of the self-contained type, should be worn when unavoidable entry is made into bunkers feeding directly into gasification vessels or carbonizing plant. Similarly suitable breathing apparatus should be worn by all persons engaged in operations when the contents of the bunker are on fire or are overheated, and entry into the bunker should, if possible, be avoided.

(4) Permits to work should be issued and should stipulate the following conditions:—

- (*a*) The work to be continually supervised by a competent person.
- (*b*) All persons engaged in the work to be made conversant with the manner in which the work is to be carried out and in the use of safety harness and safety lines.

(*c*) Each person entering the bunker to wear a safety harness, the line or lines of which should be securely attached to a firm support outside the bunker and kept taut under the control of one or more persons who should remain outside the bunker in such a position as to enable them to render immediate help if necessary.

(*d*) Suitable breathing apparatus, preferably self-contained, and at least one spare safety harness to be available for emergency use alongside the point of access to the bunker. Persons trained in the use of this apparatus should be present.

(*e*) Notices to be displayed at all control points affecting the flow of material into and out of the bunker indicating that men are at work inside the bunker. Conveyors, hoists, screens or similar machines conveying materials to the bunker should all be locked off and the key retained by the authorized person. Similarly, where practicable, bunker outlet control valves or slides should be securely shut and, if possible, locked under the control of the authorized person.

(5) In cases where the contents of the bunker are overheated or on fire, permits to work should require all persons carrying out operations from above the bunker to wear suitable breathing apparatus.

(6) Permits to work need not normally be issued for trimming operations, which should be carried out from a permanent platform or suspended cradle so arranged that the work can be done from a safe position.

(7) Permanent notices prohibiting entry except under permit to work should be fixed to all bunkers and should be regularly cleaned.

(8) All permanent platforms and other means of access should be to the standard laid down in item M6 of the I.G.E. Safety Recommendations.

(9) Rope ladders should not be used as means of access into bunkers. Some form of rigid ladder, supported from the top, should be provided when work is to be carried out. The material in the bunker should never be relied upon as a means of support; working from the surface of the material to clear blockages or restrictions of flow should be prohibited.

(10) An adequate alarm gong or other means of summoning aid should be provided for emergency use.

(11) When new bunkers are being constructed, consideration should be given to the provision of permanent platforms to facilitate trimming the contents.

Acknowledgment is made to the Electricity Council, from whose Safety Rules some of the recommendations have been derived.

SUPPLEMENT IV

MEMORANDUM ON PRECAUTIONS TO BE OBSERVED IN THE HANDLING OF CATALYSTS THAT HAVE BEEN USED IN THE GASIFICATION OF HEAVY PETROLEUM FRACTIONS

Preface

Oil-gasification plants are now in use wherein heavy fuel oil is gasified by means of a heated catalyst. "Segas" and "Onia-Gegi" plants are examples of this.

All petroleum crude oils contain vanadium compounds in amounts varying with the oil source, and these are concentrated, on refining, into the heavy fuel oil fractions; the light fractions such as primary flash distillate contain no vanadium.

On gasification, the vanadium compounds are mainly deposited with the oil ash, much of which appears in the catalyst bed and/or chequers.

Since certain vanadium compounds are toxic, there is a potential hazard to men employed in removing and handling used catalyst or in cleaning out the catalyst chambers or other vessels where ash may be deposited, apart from irritation of the skin due to the dust, especially where sweating occurs.

Symptoms of Vanadium Poisoning

(1) Greenish black discoloration of the tongue and teeth.
(2) Irritation of the nose and throat.
(3) Dry irritating cough.
(4) Mild digestive trouble.
(5) Tightness of the chest.

Protection

Protection is relatively simple and the degree of protection required depends on the conditions under which the catalyst is handled and the state of the catalyst. An authorized person should decide on the protection required under the conditions existing at the time, and the following procedure should be observed:—

I—*Breathing Apparatus*

(*a*) If the catalyst is in good physical condition and the ash deposit small, then men may be employed inside the catalyst chamber to hand pick the catalyst and sort into drums, thus preventing the raising of excessive dust and, incidentally, reducing mechanical damage to the catalyst. In this case, an approved dust mask gives adequate protection against dust inhalation. The masks must be cleaned daily after use.

(*b*) When large quantities of ash have accumulated, or when the catalyst bed has partially fused, hand sorting in the chamber may not be practicable and the catalyst will have to be shovelled out into a chute for subsequent sorting or screening. Under these circumstances, when considerable dust is raised, the authorized person should prescribe the use of some form of respirator by which air is drawn in or supplied from outside the vessel, preferably coupled with a hood enclosing the head.

(*c*) When used catalyst is being handled in the open air, an approved dust mask should be used.

II—*Clothing*

Denims or boiler suits should be worn, but taken off before leaving the plant. Any dust on this protective clothing should be removed, preferably by vacuum cleaning, to ensure that it is not breathed after the respirator has been removed.

III—*Skin Protection*

A suitable barrier cream may be applied to exposed skin surfaces before commencing work and before re-starting after washing. This is also helpful in cleansing the skin.

IV—*Washing*

Frequent washing is recommended, and baths or showers should be taken before leaving the works.

SUPPLEMENT V

AMENDMENTS TO I.G.E. SAFETY RECOMMENDATION G17 (RECOMMENDATIONS FOR GASHOLDERS)

			Act and Section, *etc.*
Page 1	Para. 3	Delete "and 1948" insert "to 1959".	
Page 2		*Title.* Delete "and 1948", insert "to 1959". Add beneath title. The following paragraphs indicate the scope of the legal requirements. In particular cases, reference should be made to the appropriate Acts or Orders.	
		Hoists and Lifts	
	Para. 2	Add "where defects affecting the safety of the hoist are reported a copy of the report must be sent by the inspecting engineer to H.M. District Inspector of Factories".	1959. S.3(1)
Page 3		*Cranes and other lifting machines*	
	Para. 2	Add "where defects affecting the Safe Working Load are reported a copy of the report must be sent by the inspecting engineer to H.M. District Inspector of Factories".	1959. S.3(1)
Page 4	Para. 2	(i) delete "and"	1959. S.4
		(ii) add "and as far as practicable be kept free from obstruction and other substances liable to cause persons to slip".	
	Para. 3	Reference now becomes 1937. S.25(3).	
	Para. 5	Add "and every such place shall, as far as practicable, be made and kept safe for any person working there".	1959. S.5
	Para. 6	Delete "10 ft", insert "6 ft 6 in."	1937. S.26(2) 1959. S.5
	Para. 7	Reference now becomes 1959. S.6(2).	
	Para. 8	Delete to end of page and insert: "Where work has to be done in any confined space which may contain dangerous fumes, unless it has been certified as being fit for entry for a specified period, the period has not expired and the person entering knows when it will expire, then he must be authorized to enter the space by a responsible person, must be wearing suitable breathing apparatus and where possible he must wear a belt with rope attached. A person capable of pulling him out must keep watch from outside the vessel and hold the free end of the rope.	1959. S.6
		Before certification that the confined space is fit to enter:—	
		(*a*) Effective steps must be taken to prevent the ingress of dangerous fumes.	S.6(5)
		(*b*) Sludge or deposits liable to give off dangerous fumes must all be removed, and	
		(*c*) the space must be adequately vented, have an assured air supply and be tested to show that dangerous fumes are not present.	
		Sufficient breathing apparatus (of a type approved by the Chief Inspector) shall be readily available. Belts, ropes, reviving apparatus and a supply of oxygen shall also be available. The breathing apparatus, belts and ropes shall be kept in good condition and shall be inspected at least once a month. The inspection report must be entered in the prescribed register."	S.6(6) Breathing Apparatus Etc. Order 1949
Page 5	Para. 1	Delete "S.27(1d)", insert "1959. S.6(7)".	
		Insert after para. 1:— "A person shall not go into a confined space where there may be a shortage of oxygen unless the atmosphere has been tested and certified as satisfactory by a responsible person and there is adequate ventilation or the person must wear a suitable breathing apparatus.	1959 S.6(9)
		No one must work in boiler flues until they have been cooled down so as to be safe."	S.6(10)
	Para. 2	Delete "1948", insert "1959".	
	Para. 3	Add "1948".	
Page 6	Para. 5	Line 6. Delete "local council", insert "fire authority". Line 10. Delete "Council", insert "fire authority". Add reference 1959 S.9(1).	
		After Para. 5 add "appropriate means for fighting fires must be provided and maintained and be readily available for use".	1959 S.12(1)
		After Para. 6 insert:— "A suitable supply of wholesome drinking water shall be provided.	1937 S.41(1)
		There shall be provided for the use of persons employed adequate and suitable facilities for washing which shall include soap and clean towels (or other means of cleaning and drying) and a supply of clean running hot and cold or warm water.	S.42(1) 1959 S.18(1)

	In difficult circumstances exemption may be obtained from this requirement.	Washing facilities (running water) Exemption Regs. 1960	
	There shall be provided accommodation for clothing put off during working hours with, as far as practicable, means for drying this clothing.	1937 S.43(1)	
	First-aid boxes to a prescribed standard must be provided. The standard varies according to the number of people employed at one time. The first-aid box shall be in the charge of a trained first-aider who shall be readily available.	S.45(1) First-aid Boxes and Factories Order, 1959	
	The standard of training is laid down to be a current St. John (or similar) certificate."	1959 S.19(1) (not yet issued).	
	After Para. 7 add "Stationary internal combustion engines must only be used so that exhaust fumes do not enter workrooms or spaces."	S.47(2)	
Page 7	Para. 3	Delete "young" and also "i.e. under 18". Add "1959 S.20".	
Page 8	Para. 7	To "1937 S.29" add "1959 S.8".	
Page 9		To "1937 S.128" add "1959 S.8".	
		To "S.131" add "1959 S.29".	
		To "S.133" add "1959 S.29".	
		To "S.136" add "1959 S.29".	
		To "S.137" add "1959 S.29".	
		To "S.138" add "1959 S.29".	
Page 23	Para. 29	Delete "volumetric control", insert "Gas volume relief."	
	Para. 33	Delete "volume control", insert "Gas volume relief."	

SUPPLEMENT VI

AMENDMENTS TO I.G.E. SAFETY RECOMMENDATION M6 (AMENDED) ("MODEL SPECIFICATION FOR PLATFORMS, LADDERS AND STAIRWAYS TO PROVIDE MEANS OF ACCESS TO PLANT")

The paragraph headed "(1) General" requires amendment as follows:—

Sub-paragraph (*a*) should now read, "safe means of access ... required by Section 26 of the Factories Act, 1937 as amended by Section 5 of the Factories Act, 1959".

Sub-paragraph (*b*) should read "fencing required by Section 18 of the Factories Act, 1937 and amended by Section 2 of the Factories Act, 1959".

Under the heading "(8) References", the reference to "Factories Acts, 1937 and 1948" should now read "Factories Acts, 1937 to 1959".

SUPPLEMENT VII

AMENDMENT OF I.G.E. SAFETY RECOMMENDATION P6 ("GUARDING OF TAR SEPARATORS")

The existing Recommendation P6 is replaced by the following:—

FACTORIES ACTS, 1937 TO 1959

GUARDING OF TAR SEPARATORS

H.M. Chief Inspector of Factories has informed the Gas Works Safety Rules Committee of The Institution of Gas Engineers that he considers that tar separators come within the provisions of Section 18 of the Factories Act, 1937. This section has been substantially modified by Section 2 of the Factories Act, 1959, and the following is a summary of the present statutory requirement:—

(*a*) The separator shall either
- (i) be securely covered or
- (ii) have its edge at least 3 ft above the level of the adjoining ground or platform, or
- (iii) be securely fenced to a height of at least 3 ft above the level of the adjoining ground or platform. (In this context, the adjoining ground or platform must be taken to be the highest ground or platform—whether contiguous or not—from which a person might fall into the separator.)

(*b*) If access across the top of the separator is required such access must be
- (i) at least 18 in. wide, and
- (ii) securely fenced on both sides to a height of at least 3 ft by upper and lower rails and toeboards or by sheet fencing.

Such access is occasionally required when light tar is produced and it is recommended that on all large tanks permanent access should be provided. If the separator is securely covered, consideration must be given to the provision of access facilities for the removal of light tar.

The attention of gas engineers is drawn to two publications that the Committee considers likely to be of interest; they are:—

(1) "Industrial Hazards in the Gas Industry", by David Llewellyn (a paper read to the Sheffield, South Yorkshire and North Midlands Section of the Royal Institute of Chemistry), and

(2) Memorandum on Explosion and Gassing Risks in the Cleaning, Examination and Repair of Stills, Tanks, *etc.*, published by the Factory Department of the Ministry of Labour and National Service.

Copies of both publications are available for consultation in the Library of the Institution.

PRESENTATION, DISCUSSION AND REPLY

Presentation

Mr. D. D. MELVIN (Chairman, Chairmen's Technical Committee), having commented on the Report prior to submitting it for discussion, made an appeal in connexion with safety recommendations published in the annual Reports of the Chairmen's Technical Committee and as constituent parts of the loose-leaf binder of gas works safety recommendations published by The Institution of Gas Engineers. " It is essential ", said Mr. Melvin, " that all previous *Communications* and binders should be kept up-to-date and that personnel at all levels, and especially newly recruited personnel, should be kept aware of the precautions necessary in their day-to-day work. It is only by constant training and reiteration that the standards set can be maintained so that progress in enhancing the high standard already achieved by our industry will be continued ".

Discussion

Mr. F. L. ATKIN (Birmingham):—Before introducing the Gas Distribution Committee's report, I should like to express its sincere thanks to the Members and senior officials of all Area Gas Boards for their considerable assistance in making available technical information and statistics on appropriate subjects. The work of the Committee would be severely handicapped if it were otherwise.

Mr. Melvin has kindly reminded us that the Report mentions that the " Recommendations for the Laying of Steel Gas Service Pipes " were issued during the year. It contains the Gas Distribution Committee's recommendation on the safest and most economical way of carrying out this essential operation. The gas industry is laying over 240,000 new services a year and over 220,000 renewals, at a total cost of some £5 mill./annum, a considerable sum. Consequently, it is surprising to find that the number of copies of these recommendations supplied is very small.

The booklet was deliberately designed to be useful to the man in the field, but it may be that in some cases it is not getting beyond the distribution engineer's bookshelves. This has been mentioned by another speaker, in connexion with the presentation and discussion of the Education Report. He spoke of " practics ", a very good term, and the booklet could be appropriately connected with the City and Guilds of London Institute examinations. To some extent, though through no inherent fault, the Institution itself may be inadvertently responsible for restricted publication, since the Institution's " blue books " have always been regarded as being " highly technical " rather than as publications on " practics." It might be that some new thinking ought to take place both in regard to presentation and publicity. In the meantime, I ask members of the Institution to note the point.

The Gas Distribution Committee has been collecting statistics on broken cast iron mains, and is grateful to the Area Gas Boards for their co-operation. Some members may also know that The Gas Council asked Sir Charles Ellis to carry out some operational research on the problem. A report has now been published and The Gas Council has been kind enough to make it available to the Gas Distribution Committee. This report confirms many of the findings of the Committee—for example, that the age of a pipe is no criterion of the necessity to replace; and that the maintenance of a high standard of mainlaying practice, including a firm bed and solid reinstatement, is necessary. Reference is also made in the report to the importance of main and service surveys. This is a subject the Gas Distribution Committee has under review.

From time to time, the work of the Panel studying the external protection of steel pipes has been mentioned. A report on this work is given as Supplement 1. The work has been very difficult inasmuch as there are numerous opinions and theories, in some cases conflicting, which are difficult to harmonize; only the passage of time will prove the correctness, or otherwise, of the opinions. Work is still proceeding, and it is possible that further information will become available. The work of the Panel has inspired the pipe wrappers, especially those that carry out their work at the tube manufacturers, to examine their existing methods, and new plant is being installed. When this equipment is fully operational, it might be that a further report will be issued.

It can be said that the fundamentals of a good bituminous wrapping are: (*a*) a good surface preparation by either mechanical or chemical means, (*b*) coating by a primer matched to the subsequent coating material, (*c*) double wrapping with two thicknesses of glass-fibre material, and (*d*) adequate temperature control. Whether the bituminous material should be asphaltic bitumen, or coal tar-based materials, is at the moment a matter of opinion. In this respect, the Committee is indebted to the Coal Tar Research Association, which has surveyed the literature and allowed the Institution to publish its findings as Appendix 1 of Supplement I of the Report. I commend its perusal to those who are interested.

The Council of the Institution requested the Gas Distribution Committee to make a survey of the present position in regard to the use of plastic pipes, especially in regard to small-diameter service tubes. This has been done, and an interim report is given as Supplement II of this Report. I would particularly draw attention to the conclusions reached.

It will be appreciated that the ball is now in the court of the plastic manufacturers. This new and virile industry must have many problems on its hands. It is believed that the techniques of the tube extruders are satisfactory; therefore, it is a matter of suitable raw materials and cost. It is hoped that this interim report, which has been made available to the manufacturers of plastics and been generally accepted by them as a fair statement of facts, will spur them on to further efforts.

It has been suggested by pipe manufacturers that some of the cracks appearing in the larger-diameter pipes during testing are due to the transportation and handling of pipes. While not subscribing wholly to this view, the Cast Iron Pipes Liaison Committee has studied the subject and in conjunction with the manufacturers, produced *Communication No.* 575 (" Recommendations on the Transportation and Handling of Cast Iron Pipes "). This is profusely illustrated and is meant to be useful at all levels, including storekeepers, gangers, and lorry drivers. Again the Gas Distribution Committee appeals to members to give this booklet the widest circulation. It cannot do anything but good.

Mr. T. C. BATTERSBY, M.B.E. (Watford):—First, I would thank Mr. Duncan Melvin, the Immediate Past President, for his generous appreciation of the work done by the many Committees and Panels concerned with the technical aspects of the gas industry. I would acknowledge also how much the work of the Gas Works Safety Rules Committee is helped by the close liaison we enjoy with the Gas Council Committees and Her Majesty's factory inspectorate.

Reference has been made in the Report to the efforts of the Councils of The Institution of Gas Engineers and of The Coke Oven Managers' Association to achieve closer collaboration between the two organizations. These sister interests have many common hazards, and it is known by The Institution of Gas Engineers that our safety recommendations are to be found on the shelves of many coke oven managers. Accordingly, it is with considerable pleasure and satisfaction that the Committee has welcomed two new members—Mr. F. K. Illingworth and Mr. H. J. Victory—appointed, at the invitation of the Institution's Council, by the Council of The Coke Oven Managers' Association, and I should like to thank these gentlemen for the valuable contributions they have made to our deliberations since they became members of the Committee.

New recommendations and amendments to existing recommendations are published from time to time during the year, and they are reproduced in the annual Reports of the Chairmen's Technical Committee. I trust this will not be considered unnecessary repetition, for by this means it is hoped that they will not escape the attention of any member.

As manufacturing units increase in size, the hazards associated with fuel storage assume more serious proportions. Regrettably, several operatives have lost their lives when working in bunkers. In March of this year, Recommendations on Safe Access to Hoppers and Bunkers were published and are included as Supplement III of this Report.

New gas-making processes bring their peculiar hazards, and the deposition of vanadium compounds is a case in point. All petroleum crude oils contain vanadium compounds, the amount varying according to the origin of the oil, and on refining are concentrated in the heavy oil fractions. On gasification, the vanadium compounds are mainly deposited with the ash found in the catalyst bed or chequer work of gasification plants. These compounds are toxic, and precautions are necessary when handling used catalysts or when cleaning out vessels where such ash may be deposited. The Institution's Safety Recommendation M10 (" Memorandum on Precautions to be Observed in the Handling of Catalysts that have been Used in the Gasification of Heavy

Petroleum Fractions ") was published in March and is reproduced as Supplement IV of this Report.

When the " Memorandum on Installations for the use of Light Petroleum Distillate in Low-pressure Gasification Plants " (M9) was prepared, the Committee envisaged the delivery of this feedstock by road tanker, and generally this is so, but there are some destinations where delivery is effected by rail tankers or by ships and it is accordingly necessary to amend that part of the recommendation that is inappropriate for off-loading from such vessels. The full text of this revision of sub-section (3) of Section 2 of M9 is reproduced as part of the report on the work of the Gas Works Safety Rules Committee.

The Factories Acts contain provisions of particular importance to the gas industry, which may impose grave responsibilities on employed persons, particularly those responsible for the safe conduct of the work. At the present time, the Gas Works Safety Rules Committee is reviewing all of the recommendations in the light of the requirements of the 1959 Factories Act, and amendments are published as Supplements V, VI and VII of this Report.

Recently, the Committee revised Recommendation M4 (" Code of Practice for the Safe Opening of Gas Works Plant "), and shortly an amended version will be published.

A few weeks ago we were informed that the Illuminating Engineering Society intends to revise its code for the lighting of buildings, and the Society sought, for the first time, the Committee's advice in connexion with the lighting of gas works buildings. A panel was appointed to consider the matter, and lighting standards have been submitted to and approved by the Council of the Institution and communicated to the Illuminating Engineering Society.

Again this year, on behalf of the Gas Works Safety Rules Committee, I should like to thank the Area Gas Boards for their helpful co-operation in making available to us details of accidents that have occurred at their works. From a study of this information, the Committee may feel it desirable either to prepare a recommendation, or to focus attention on a particular hazard through the medium of the booklet series " Unusual Incidents at Gas Works and their Lessons ". A third collection of such incidents was published in October, 1959, and it is gratifying to know that it has received such a wide circulation throughout the industry.

I would stress that no incident is too small to report to the Committee. The lessons to be learned may be the means of preventing a more serious accident or even a fatality.

Members will recall that the *ad hoc* Committee on Electrical Bonding reached the conclusion that segregation of the services supplying buildings was an ideal difficult to implement in practice, and accordingly recommended that it would be safer to cross-bond the gas, water and electricity services.

After acceptance of its recommendations by The Gas Council, the Committee was directed to seek discussions with representatives of the Institutions of Electrical Engineers and of Water Engineers. The first tripartite meeting took place in March, 1959. After presenting the *ad hoc* Committee's recommendations, it was agreed that the representatives of the electricity and water interests should be allowed time to study the proposals and to report to their respective Councils.

Since that time, informal meetings have taken place with The Institution of Electrical Engineers, chiefly to clarify technical details, but meanwhile both gas and electricity representatives have made parallel enquiries as to the current practices throughout the country. These investigations show that crossbonding of the utility services exists in some districts, but, possibly unknown to either the gas or electricity Area Boards, and even within the province of an Area Board, there is no uniformity of practice.

The last tripartite meeting was held last week, and it would be fair to say that considerable and encouraging progress was made. A further meeting will be convened early in 1961, when, it is hoped, we shall have the considered views of the Electricity Council on this matter.

This may be the last occasion on which I shall be reporting to an Autumn Research Meeting as Chairman of the Gas Works Safety Rules Committee. I should like, therefore, to express my thanks to all who have assisted me in this work. I have enjoyed the work on the Committee, and recently, as Chairman, it has given me very much pleasure to preside at the many meetings. I should also like to thank the many Presidents under whom I have served in this capacity, and also the members of the Committee who have devoted so much time to the work. I do not think it is generally appreciated that some of the draft recommendations may run to as many as ten or twelve editions before they are finally submitted to the Council of the Institution.

It has been a wonderful Committee to serve on. All the members are essentially individualists and specialists fired with one common purpose—to make plant operators' lives safer within the industry.

I should particularly like to thank Mr. A. G. Higgins, Assistant Secretary of the Institution, who has wrestled with its minutes and drafts for so many years.

The PRESIDENT, addressing Mr. Battersby, said:—I was very sorry when you told me that you felt it necessary to relinquish the chairmanship of this Committee. On the other hand, I realize, and we all realize, that your commitments are such that it is not possible for you to continue with the office. I should, however, like to take this opportunity to thank you very much indeed for all the work you have done. I had the pleasure of serving under you on the Committee for some years and I know it is a very hard-working Committee. Thank you very much.

Mr. J. E. DAVIS, O.B.E. (Croydon):—The work of the Codes of Practice Sub-Committee is by no means the most spectacular work carried out by the standing Committees of the Institution. Nevertheless, its value would certainly not be underestimated by those members of the commercial staffs of Area Gas Boards who are in daily contact with architects and housing authorities. It is the real value of this link which has led the Council to agree to an increase in the representation of such bodies on certain of the drafting Panels.

Codes of practice for buildings were instituted towards the end of the Second World War, and those of us who attended the original briefing meeting were encouraged by the comment: "You will never know what a code of practice is until you start to write one". This has proved very true. We are all inclined to be certain that we know the best way of doing a job until we discuss it with colleagues of equal competence. Then we realize how wide a variety of " best " ways there can be. The reconciliation of views is the work of the drafting Panels, and, as I personally no longer serve on any of them, I can commend the keenness and quality of their work for approval and appreciation.

On the progress of the work itself, I would refer only to the continued delay in publishing the revised Code on Gas Installation Pipes, the reasons for which are explained in the Report and were mentioned by Mr. Battersby. It begins to look as though the negotiations with other interests may be long-drawn-out, and we are hoping that it will be possible to issue the revised code in such a form that amendments to take account of final agreement may be made with ease.

I would make a brief comment on Supplement II of the Report, dealing with the subject of plastic pipes. As it stands, I am inclined to the opinion that it pours rather unnecessarily cold water on this interesting new development. Recognizing the need for caution in adopting novel techniques, one must take note of the fact that there have been some failures, but we should also remember that there have been many successes.

In certain circumstances, polyvinyl chloride pipes are attacked by hydrocarbon vapours. The plasticized or modified P.V.C. pipes are much more susceptible than the unplasticized material. Laboratory work is now in progress, at Old Kent Road, for The Gas Council, to define the conditions under which attack is likely and the conditions under which attack is not at all likely to occur. Aromatic hydrocarbons are known to have a much larger effect than paraffinic hydrocarbons. If the concentration of hydrocarbon vapour approaches saturation, deterioration of the plastic is rapid, but as the vapour pressure moves away from saturation the effect decreases rapidly, and at 60 to 70 per cent of saturation the plastic is scarcely affected at all. This fact has been demonstrated experimentally for atmospheres containing single aromatic hydrocarbons, but the effect of mixtures of hydrocarbons displays a more complex behaviour, which is still under investigation. It is possible at this stage to state firmly that coal gas which has been stripped of its benzole content is not likely to have any effect upon unplasticized P.V.C. This view is borne out by practical experience. It is probably true that any gas which has been oil-washed, or otherwise treated, to remove the higher-boiling aromatics will be equally safe to use. Looking ahead, when distributing engineers will be

using higher distribution pressures, more unmanned holder stations and more remote control, it is to be expected that they will demand a gas which does not, on compression, deposit liquid hydrocarbons and does not contain gum-forming constituents such as styrene. Compliance with these requirements is very likely to ensure a gas composition with which unplasticized P.V.C. can safely be used. Meanwhile, the search for improved plastics not affected by any likely gas constituent will continue.

Mr. A. V. HORSFALL (Birmingham):—Unaccounted-for gas still seems to remain a very controversial issue in the gas industry. It was in 1938 that the Institution first published an interim report on unaccounted-for gas, and this was followed by the appointment, in 1950, of a sub-Committee whose terms of reference were to revise and enlarge the interim report and to include a note of the methods for reducing unaccounted-for gas.

The sub-Committee produced its report, which was issued as the Institution's *Communication No.* 380, in July, 1951, and since that time the industry has operated to the suggestions and various formulae then produced for assessing unaccounted-for gas both as regards estimated physical losses and accountable losses. As a fairly general rule, it had been noticeable that the smaller production and distribution unit frequently had the higher percentage of gas unaccounted for.

Nationalization of the industry, in 1949, led fairly rapidly to the closing of small works, integration of distribution systems and concentration on large production units, together with improved means of measurement, both on works and in consumers' meters. The way seemed to be open at least to expectation of reducing losses of unaccounted-for gas.

From 1949-50 to 1958-59, however, with one or two exceptions, gross unaccounted-for gas losses have increased. There can be little doubt that this perplexing situation focused attention once again on the problem, from which, if the answer can be found and remedial steps taken not merely to reduce losses by arithmetical calculation, but also to reduce physical losses and produce revenue for usage as opposed to wastage, the industry must benefit.

In late 1959, therefore, the Institution again invited a Committee to review the situation, with the following terms of reference:—

> "To study the problem of unaccounted-for gas in all its aspects and to recommend ways of reducing it."

The Committee is well aware of the somewhat formidable nature of its task to comply with the terms of reference. The Committee first met on 3rd December, 1959, and has by now held five meetings. In its earlier discussions, it was decided that, if a value could be placed on the various accepted causes for unaccounted-for gas, it might show some excess left over, which could be the subject of further investigation and even suggest some remedy by way of positive action.

The first task of the Committee, therefore, has been to concentrate attention on known possible causes affecting unaccounted-for gas losses. A statistical appraisal indicates the following assessment of losses on a very broad basis:—

- 32·5 per cent from temperature conditions on consumers' meters.
- 12·5 per cent loss in consumers' premises.
- 55·0 per cent loss from other causes including distribution systems and holders.

It is emphasized that these are not empirical figures; they are merely a guide for further investigation. Regarding measurements by meters, the point emerges that the temperature at which gas is measured may have considerable influence on unaccounted-for gas figures. The difficulty is that little reliable information is available that provides accurate temperature conditions met with in practice, but information is now being provided to the Committee, which will considerably assist its final conclusions; it may well be that, in order to assess fully the effects of geographical location on gas stream temperatures at the point of measurement, the assistance of Area Gas Boards will be sought to provide further information.

On the question of losses in consumers' premises, evidence from tests already taken indicates the possibility of an average carcass leakage of about 0·035 cu. ft/hr per consumer. This rate of leakage, or what I should prefer to call seepage, is well below that rate which even a modern meter would be expected to register. The modern meter will register with a high degree of accuracy down to 0·1 cu. ft/hr, but, of course, modern meters are not universally installed. To indicate some idea of the importance of low seepage rates from carcasses and appliances, a loss of 0·15 cu. ft/hr per consumer would account for all the present unaccounted-for gas. Quite obviously, this does not occur, since there are other well known sources of loss, which contribute to the overall figure.

In recent years, Area Gas Boards have carried out considerable investigation, with leakage surveys using the explosimeter, into leakages from mains and services, and the evidence forthcoming from these surveys indicates about three to five leakages per mile of main at rates from 0·5 to 8 cu. ft/hr. In 1917, the late Stephen Lacey carried out similar tests for mains leakage and found that, on old mains that had been thrown out of use to provide special purposes for the test, the rate of leakage varied from 27 to 72 cu. ft/annum per foot run of joint. In his opinion, at that time the mains tested were in relatively bad condition. In spite of that, however, he surmised that, even if all the mains in the then area of the Gas Light and Coke Company were in similar condition, and this was unthinkable, the contribution to unaccounted-for gas from such causes would represent only 0·75 per cent of gas made. Recent leakage surveys indicate that Stephen Lacey was correct in his conclusions.

The Committee is also investigating the contribution to unaccounted-for gas from incorrect registration of meters, and, although it is too early to draw conclusions, indications are that the domestic meter does not contribute, by not more than about 1 per cent, to unaccounted-for gas. The position may be different with industrial meters, where tests already made indicate some high rates of passing unregistered gas, but it could well be that this contribution is of small significance.

There is also the question of leakage from holders, and, once again, the Committee has been fortunate in having had placed at its disposal, by one Area Gas Board, facilities for testing holders under fully inflated sealed conditions.

There is also the problem of possible application of more accurate means for assessing unread gas, and on this subject it is considered that the use of electronic accountancy methods, together with some adjustment of the existing unread-gas formula, may give more accurate results, which at present are not possible, bearing in mind the vast amount of work required when manual calculation is used.

It will be obvious that the Committee still has considerable work to do, and, since some of the investigations may be long-term in character, it is possible that an interim report could with advantage be made.

Written Contributions

Mr. T. N. DENT (Bath) wrote:—The Report as published gives a comprehensive, but modest, picture of the great amount of useful work done by the Meters Committee together with its sub-Committees during the past year, which is really a continuation of the previous year's work.

The meter-performance survey, which is now being carried out on " in dates," should provide useful information to the gas industry and the meter manufacturers, for the following reasons:—

As all the meters examined will be less than five years old, the survey will cover the newer types of meters, both of traditional and non-traditional construction and design.

For the same reason, these meters will have been operating on new types of gases now being distributed in all parts of the country.

The small-case domestic meter will come within the survey, and it will be of interest to learn how these meters are standing up to district conditions, especially regarding their comparatively high speed of working on maximum load.

The tests on industrial meters, which it is now proposed shall be carried out, will prove whether it is good policy to allow an industrial meter to work continuously on a 20 per cent overload condition, taking advantage of the fact that, gas being of a lower specific gravity than air, a greater quantity of gas can be passed through a meter with no increase in pressure loss.

Whilst standard dimensions for small-case meters have not yet been finally settled, it would be of great advantage to the Area Gas Boards for the dimensions between inlet and outlet bosses to be the same as for D.1-size meters, and I hope that we shall have a decision in this direction before very long.

The Watson House Meters Sub-Committee, of which I am privileged to be chairman, has continued to work in parallel and in close liaison with the Institution's Meters Committee.

The draft requirements for domestic meters, covering both construction and performance, have nearly passed through all the final stages and should be published in the near future.

In the meantime, this sub-Committee is concerning itself with investigations into valve-drag, thickness of tinning, alternative materials for meter diaphragms, and the effect of condensates in meters.

The South Western Gas Board is carrying out a certain amount of investigation into condensates on its gas-liquid chromatography apparatus, in its Central Laboratory and, of course, in collaboration with Watson House. Since the Board is manufacturing six different types of gases at present, together with injection of primary flash distillate into all types of vertical retorts, the effect of varying gas characteristics and condensates on meters is of vital importance in the Area, as indeed it will be to other Area Gas Boards.

Finally, I hope that, now that the question of royalties has been settled, we shall see during the coming year a more active interest in the important development of the one-pipe principle of connexion for British-made meters, and with this a trend towards a greater streamlining in meter case design, which will tend to make the domestic meter a rather less unpleasing piece of apparatus to be installed in the home.

Mr. B. J. FULLER (Watford) wrote:—The Gas Works Safety Rules Committee is a fine body, but an all-too-modest one. Each year, its informed Report and recommendations on safety matters in our industry is to be found in the agenda of the Autumn Research Meeting under the uninspiring title " Report of the Chairmen's Technical Committee ", and limited opportunity is given for discussion.

Mr. Melvin has already enumerated the recent additions to the safety recommendations, and I should like to endorse his remarks about the use of these recommendations by sounding a note of warning. No gas engineer's bookshelf is complete without a volume of The Institution of Gas Engineers Safety Recommendations. It is a book to be used, to be kept up to date, to be studied, to be acted upon!

I have often heard engineers say: " These are only recommendations, not regulations; they are not law ". With this attitude one is living in a fool's paradise. As an employer of labour, one has a duty at common law to establish and enforce a proper system or method of work. That is what The Institution of Gas Engineers Safety Recommendations are, and it may be of interest to members to be reminded of Mr. Justice Glyn-Jones' comments on the recommendations, in a recent judgment. He said:—

> " It will be noticed that this is not a code of regulations made by a Government Department and imposed upon the industry which may think the decisions of the code unnecessary or unreasonable. These are voluntary regulations drawn up by The Institution of Gas Engineers, which, I suppose, means engineers employed by the defendants belonging to it, and the recommendations are such as gas engineers in their own estimation think reasonable. . . . "

The learned judge outlined the operations undertaken, which did, in fact, partly conform to the safety recommendations, but was critical of the lapse of time in fulfilling the requirements of the recommendations to the letter, and gave judgment against the Gas Board. This indicates the importance attached to these recommendations in a court of law.

On the human side, a study of the numbers of fatal accidents in the gas industry in the three years 1949 to 1951—the first collected volume of recommendations was published in 1950—compared with the fatal accidents in the last three years is revealing. During the first three-year period, 86 people were killed, an average of just under 29 per year; in the last three years, 34 people were killed, an average of just over 11 people per year. I suggest that the safety recommendations have played no small part in this improvement, but we still have a long way to go.

I have only one suggestion to offer on the safety recommendations in their present form. They have now become a substantial volume, and I suggest that consideration might be given to the provision of a classified index for easy reference.

During the year, the Committee has also published a third excellent booklet on " Unusual Incidents at Gas Works and their Lessons ". This booklet serves a most useful purpose in drawing attention to accidents and the means to avoid them. My criticism of this work is that it is too " kid-gloved ". There is nothing fancy about an industrial accident; it is a crude affair, somebody gets hurt, sometimes killed. The publishing of a 34-page booklet once in five years describing 26 incidents is only scratching at the surface of the problem.

During the interval between the publication of parts II and III, 55 people have been killed and almost 15,000 injured in accidents reported to H.M. Factory Inspectorate by the gas industry. I suggest that particulars of these accidents should be published at more frequent intervals, with fewer incidents in each book, more graphically illustrated, so that a busy engineer, who is already bombarded with paper in one form or another, might have an opportunity of reading the booklet from cover to cover in one sitting. In its present form, this is usually not possible, and even with the best will in the world the book is often never completely read.

For the accidents with more far-reaching effects, consideration might be given to the preparation of film-strip lectures and lantern slides, so that the knowledge gained might be spread to the widest audience, which means every worker.

The Committee acknowledges with gratitude the helpful co-operation it receives from all Area Gas Boards, but I suspect that only a fraction of the incidents that occur reach the ears of the Committee.

It is an unfortunate fact that many engineers consider an accident, or unusual incident, a reflection on their efficiency, and, if no one is hurt sufficiently seriously to make it reportable, an incident is " hushed up ". I remember an incident some years ago when a truck-load of frozen coal weighing some 24 tons gross was tipped completely, coal and wagon, over a side wagon tippler; fortunately, no one was injured. This would, to my mind, be of sufficient importance to merit inclusion in " Unusual Incidents at Gas Works ", but it has never been included and I doubt whether it was even reported to the Committee as no one was hurt. This type of incident is surely of interest to the Committee, and, if such a report were accompanied by photographs and drawings, the rest of the industry could benefit to the full.

In conclusion, I should like to thank the Committee for the grand job it is doing. It is no easy matter to frame recommendations for an industry with so many varieties of plant and sizes of works, from mighty Beckton to the works with a staff of one man and a cat, but this is what the Committee successfully does.

Finally, I make a further plea for the medicine " Unusual Incidents at Gas Works and their Lessons " in smaller doses at more frequent intervals, and may engineers in this great industry pay the Committee the compliment of taking the full dose of the medicine regularly so as to gain full benefit from it.

Mr. K. L. PEARCE (Derby) wrote:—I should like to draw particular attention to the two publications prepared by the Gas Distribution Committee, namely, " Recommendations for the Laying of Steel Gas Service Pipes " and " Recommendations for the Transportation, Handling and Storage of Cast Iron Pipes ". These and similar valuable publications that the Committee has prepared for guidance of the industry on distribution methods and techniques, represent considerable thought and effort by responsible distribution engineers, and I urge strongly that the recommended practices set out in these publications be widely circulated and adopted in the field, and that the publications shall not merely lie on the shelves in engineers' offices.

The importance of good mainlaying practices, which, incidentally, are adequately dealt with in an earlier publication entitled " Recommendations for Mainlaying " (*Communication No.* 491), is again underlined in the interesting and valuable Report prepared for The Gas Council by Sir Charles Ellis and Mr. John Power, following their researches into the fracture of gas mains.

The work of the Panel appointed by the Committee to consider the external protection of steel tubes, has undoubtedly produced satisfactory results in that suppliers are now marketing a far more durable article in the double-wrapped tube than was the case prior to the Panel commencing its work. It seems to me that the heavy financial burden carried by the industry in replacing corroded steel service pipes arises from the use of a material that is extremely

susceptible to corrosion when laid underground, and the protection needs to be more than a palliative.

The Committee refers to the present position relating to the use of plastic materials in the manufacture of service pipes, which so far have not been found to be satisfactory for conveying town gas. A number of tests using plastic pipes are in progress in various parts of the country, and the East Midlands Gas Board has been investigating this problem for some time and can confirm some of the Committee's findings referred to in Supplement II of the Report. It is fair to say, however, that progress in the development of plastics has been rapid in other fields, and it is hoped that the production of a plastic pipe suitable for conveying town gas will not be too long delayed. The variety of gases at present distributed by different Boards does not make the problem any easier, but I am sure the Committee will continue to pursue the answer to this question, as the potential advantages to the gas industry are considerable.

Finally, I feel that any comment on the work of the Gas Distribution Committee would be incomplete without reference to the work that is going on in pipe manufacturers' premises towards the production of pipes made of spheroidal graphite or ductile iron. Evidence has been obtained, from various parts of the world, that indicates that the corrosion resistance of this material is not less and may be better than the present spun iron materials. I am sure that the Committee will keep this matter constantly under review so that advantage may be taken of this new material for distribution purposes, assuming that the costs involved are reasonably close to present-day costs of materials in current use.

Chairman's Written Reply

Mr. D. D. MELVIN (Chairman, Chairmen's Technical Committee) wrote in reply:—Mr. Pearce and Mr. Davis have both commented on the behaviour of plastic tubing, and the outline of the progress of the experiments and work in hand at Old Kent Road are of great interest. The circumstances under which unplasticized material can be used without any ill effect can now be more closely defined, and the treatment likely to be required for gas made when these materials are to be used does not seem unduly onerous. Experiments and discussions will continue and there seems little doubt that these new materials may, in time, provide a cure for the internal and external corrosion troubles that affect service pipes in particular.

The major Committees on Gas Works Safety Rules, Gas Distribution and Meters have each one nominee from each Area Board included in their membership. It is, therefore, possible, when discussing problems or recommendations, to have knowledge of the practice in all Areas, and any subsequent conclusion that takes account of all factors and difficulties is more likely to be adopted and implemented.

Reference has been made to the desirability of couching some of the Institution's instructions in more mandatory terms. The Council and the Committee have this point very much in mind. So far, and in the present stage in the development of the gas industry, it has been thought desirable to continue the practice of making recommendations and not regulations. Matters of principle, and sometimes matters of law, are involved and have to be kept in mind. The comment by Mr. Justice Glyn-Jones in a recent judgment, which Mr. Fuller has quoted and discussed in such a straightforward way, brings out more clearly the importance attached to these safety recommendations. The process of education in these matters continues and it is pleasing to know that the efforts of those who devote their time and energy is so much appreciated.

The progress reported by Mr. Horsfall of the work of his Committee on Unaccounted-for Gas gives some indication of the probable sources of the major losses or discrepancies, and we shall await with interest the result of further investigations being made. It has been proposed and agreed that an accountant be invited to serve on the Committee and so bring experience of the arithmetic of the problem and the possible use of computation towards its solution.

In his contribution, Mr. Dent brings us up to date with the present work on the testing and development of meters, both for domestic and industrial purposes, and his comments are appreciated. There is much to be said for this streamlining of design, and, if the technical dimensions can be accommodated within an acceptable pattern, much progress can be made.

It seems clear that greater publicity may require to be given, first, to the necessity for a greater interchange of information on accidents and unusual incidents, and, secondly, to developing ways and means of ensuring that the Institution's booklets on this subject have a greater circulation and reach the people who carry out the work. Perhaps " popular editions " of some of the more important codes may be required.

We are all sorry to hear of Mr. Battersby's intention to resign from the office of Chairman of the Gas Works Safety Rules Committee, although we can well appreciate his reasons. We shall have an opportunity later to pay tribute for his services in this capacity. Under his leadership over the past six years, the work of his Committee has gone on from strength to strength and its publications have reached a very high standard. We hope, however, he will still be associated with the work of the *ad hoc* Committee on Electrical Bonding, particularly in view of the stage reached in the negotiations of this rather involved problem.

I should like to express thanks to those who have taken part in the discussion of this Report. The points that have been made will receive consideration by the Council and the appropriate Committee.

EXPERIENCES WITH BRANCHED-FLUE AND SE-DUCT SYSTEMS FOR VENTING GAS APPLIANCES

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I SUMMARY

This paper differs from its predecessors in that it is mainly concerned with the verification, in the field, of predictions and design data for shared flue systems established as a result of theoretical and laboratory work. Several installations in blocks of flats have been fully instrumented, and their behaviour observed, sometimes in great detail, over a considerable period of time.

Section III of the paper is concerned with branched-flue systems, mainly for gas appliances but also for use with solid fuel, and represents a continuation and confirmation of work already reported. Modified design data are presented in the light of experience, which should further assist their application.

Section IV is concerned with a number of Se-Duct systems; it is based primarily on the installation at Gateshead, but with strong supporting evidence from several others, giving variety in location, height, type of appliances, and so forth. The results fully support design predictions and lead, in certain cases, to slightly reduced duct sizes and simplified base duct arrangements. Section V deals briefly with a U-Duct installation.

In Section VI, broad conclusions are drawn from the foregoing which may be summarized in the simple statement that theory and prediction have been fully confirmed in practice and some valuable practical lessons have been learned.

Problems of instrumentation, air flow tests with models, appliance usage factors, and certain theoretical aspects are dealt with in appendices to the main paper.

II INTRODUCTION

The problem of the disposal of products of combustion from domestic gas appliances, which have a high gas rate or which operate continuously for long periods of time, has for many years exercised the gas industry.[1, 2] The present paper is the latest in a post-war succession[3–7] that have had a two-fold objective : (i) to establish on a sound theoretical basis the fundamentals of individual flue design, and (ii) to extend this study to a variety of shared-flue systems. The trends in building practice, and in particular the increased construction of multi-storey dwellings, which have lent urgency to these studies, have been discussed in previous papers and need not be repeated here.

This paper is primarily concerned with the translation into practice of the ideas put forward in the earlier papers, and with the verification of theoretical and laboratory predictions under practical working conditions. This " practical" stage introduces at least four new factors. In the first place, the construction of a flue or duct system with the fitting of the gas appliances is only one of a vast number of operations occurring concurrently on a building site, and the flue must take its chance with the rest. If the procedure is too vague or complex, or too dependent upon finesse, the result may be below expectation. In the second place, the practical trials reported in this paper have involved a considerable measure of extrapolation, which, scientifically speaking, is not a happy procedure. The tallest individual flue investigated at the laboratory stage was 80 ft ; the tallest branched flue 40 ft ; the tallest Se-Duct 50 ft. The West Ham flats are 80 ft high, those at Harlow 120 ft, and those at Finsbury 160 ft. These figures are a measure of the venture into the unknown. Thirdly, all practical installations are subject to wind and weather, both of which are notoriously unpredictable variables. Finally, the manner and pattern of use of the appliances is determined by the ultimate occupants of the dwellings, who go about their daily lives according to their own whims and habits, unaware that the hopes or fears of the technician rest upon their unpremeditated actions.

In one sense, this work can never be complete, because there will always be further possible combinations of building requirements, weather conditions and appliance usage factors. Nevertheless, sufficient experience has now been gained to warrant this paper, and if justification is needed it may perhaps be found in the uniformly encouraging nature of the results to date and in the urgency of this information to the gas industry at the present time.

More work remains to be done, and prolonged observation may be necessary before all possible combinations of wind and weather have been explored. These studies will be carried to a greater overall height in the 17-storey Se-Ducts at Finsbury ; to a still greater heat input to the Se-Ducts at Poplar ; to the " neutral zone " inlets at Kilburn ; and to the 11-storey branched flues at Kirkby, Liverpool. This further work may modify present conclusions in detail, but is unlikely to lead to any major alterations in principle, except in the direction of simplification.

Newcastle-upon-Tyne : Multi-storeyed Blocks Containing Se-Ducts.

III THE BRANCHED-FLUE SYSTEM

(1) FIELD TESTS

The theoretical approach to the design of branched flues, outlined in an earlier paper [4], showed that, although the analysis was complex, very good agreement could be obtained between predicted results and experimental measurements on laboratory installations. However, the calculated figures required that the ambient pressure conditions prevailing at the terminal and in the rooms connected to the system could be specified. In practice, these vary considerably and are affected by fluctuations in wind speed and direction, the presence of neighbouring structures and the random openings of doors and windows.

To design systems on the assumption of the most adverse pressure conditions would result in uneconomical constructions, and would be unjustified if such conditions occurred for only a few minutes in the course of a year. In practice, therefore, design has been based on more realistic assumptions, and the principal object of the field tests on actual installations has been the essentially statistical one of establishing whether these assumptions are justified.

The conditions themselves are of less importance than the effect they produce in the flue system, and for this reason the pressure difference occurring between a subsidiary flue of the system and the corresponding room was taken as the criterion of performance. Thus, when the flue pressure was of greater magnitude than that in the room, a downdraught or " adverse pressure " was recorded ; similarly, when the room pressure was greater an updraught was observed. A detailed discussion of the problems of pressure measurement in flues has also been given previously [6] and is further considered in Appendix 1.

A secondary object of the district trials was to record the usage of the appliances connected to the system. This information was required for two reasons : (i) it is necessary to know the conditions of appliance usage obtaining when downdraught is occurring in the flue, and (ii) the maximum number of appliances likely to be in simultaneous use will have an important bearing on design dimensions of the system.

(A) THE WESTMINSTER INSTALLATION

The first branched-flue systems for gas appliances in this country were installed at Westminster, in 1956, for the venting of bath water heaters and have already been fully described. [4, 6] Records have continued to be obtained on the asbestos-cement system, where it was found that, after 2,300 hr of records on the flue of the second heater from the top, downdraught was registered for a total time of 11½ hr or about 0·5 per cent. At no time did this exceed 0·005 in. w.g. in magnitude except for occasional " puffs " of instantaneous duration.

A striking comparison between the performance of branched and individual flues was obtained on this installation. In flats constructed with bathrooms adjacent to, and having the same outlook as, those joined by the branched-flue system, similar appliances were vented *via* individual flues with wall terminals. Pressure measurements on the individual flues were obtained over a similar period, and it was observed that, over 2,386 hr, downdraughts of up to 1/100 in. w.g. were recorded for a total of 494 hr, or more than 20 per cent of the total time.

(B) THE WEST HAM INSTALLATION

The branched-flue system serving high-efficiency gas fires in the eight-storey block of flats at West Ham has also been described in detail. At the time of the earlier report, [6] only preliminary figures were available of the pressure records, and the latest figures, obtained after nearly two years' experience, are summarised in Tables 1 to 3.

It can be seen, from the complete pressure records, that during the winter periods downdraught was virtually non-existent even when the fires were not in use. Excluding the individual flue, the greatest proportion recorded in that period was less than 1 per cent of the total record time. In the summer, somewhat greater proportions of downdraught were recorded, but these were clearly due to temperature reversal effects and to the opening of doors and windows on the leeward side of the building.

Similar results were obtained with the fires in use, although in this case a somewhat higher standard must be maintained to avoid spillage of the combustion products. An updraught of 0·005 in w.g. has been taken as a criterion for ensuring adequate clearance of the products. Even with this condition, the winter records show that, excluding the top appliance, satisfactory clearance was generally achieved for more than 99 per cent of the time. When it is remembered that the total spillage was composed of numerous periods of a few minutes on first lighting the appliance, it is apparent how completely satisfactory was the operation of the system.

Details of the usage of the fires are given in Table 3, from which it will be observed that, although the simultaneous usage of all eight fires was a rare occurrence, it did take place at times during the winter period. It is clear, therefore, that, certainly in the case of medium-height buildings, the possibility of the simultaneous usage of all the space heating appliances must be allowed for in the design of the flue system.

TABLE 1.—*West Ham : Adverse Pressure Under All Conditions*

Flue	Record Time (hr)	Adverse Pressure (in. w.g.) greater than : 0·000	0·005	0·010	0·020
1	2	3	4	5	6
WINTER	1958–59	Per cent	Per cent	Per cent	Per cent
1	898	0·0	0·0	0·0	0·0
2	758	0·6	0·3	0·1	0·0
3	969	0·2	0·1	0·0	0·0
4	829	0·1	0·1	0·1	0·0
5	820	0·0	0·0	0·0	0·0
6	822	0·1	0·0	0·0	0·0
7	861	0·2	0·1	0·0	0·0
8	861	1·0	0·3	0·1	0·0
SUMMER	1958–59				
1	820	2·9	0·6	0·2	0·1
2	934	7·4	4·2	2·2	0·6
3	796	6·1	2·1	0·8	0·3
4	854	9·1	1·6	0·8	0·3
5	784	3·6	1·9	1·1	0·7
6	767	2·0	0·7	0·3	0·1
7	823	3·1	1·9	1·4	1·0
8	803	4·4	2·6	2·1	1·4
WINTER	1959–60				
1	832	0·1	0·1	0·0	0·0
2	694	0·0	0·0	0·0	0·0
3	835	0·8	0·4	0·2	0·1
4	736	0·0	0·0	0·0	0·0
5	846	0·1	0·0	0·0	0·0
6	846	0·3	0·1	0·0	0·0
7	833	0·5	0·2	0·1	0·0
8	833	3·7	1·6	0·7	0·2

Notes : (1) Flue 1 is connected to the bottom appliance. Flues 1 to 4 are vented into one main flue, flues 5 to 7 into a second ; flue 8 is an individual one connected to the top appliance.
(2) The summer period for 1958-59 was taken as July to September, 1958, and April to June, 1959.

TABLE 2.—*West Ham : Pressure Records with Fires Alight*

Flue	Record Time (hr)	Updraught (in. w.g.) less than 0·005	Adverse Pressure (in. w.g.) greater than 0·000	0·005	0·020
1	2	3	4	5	6
WINTER	1958–59	Per cent	Per cent	Per cent	Per cent
1	331	0·1	0·0	0·0	0·0
2	284	0·9	0·4	0·1	0·0
3	438	0·7	0·2	0·1	0·0
4	390	0·6	0·3	0·1	0·0
5	481	0·0	0·0	0·0	0·0
6	481	0·4	0·0	0·0	0·0
7	413	0·4	0·1	0·0	0·0
8	215	2·8	0·5	0·1	0·0
SUMMER	1958–59				
1	131	0·4	0·0	0·0	0·0
2	160	2·7	0·8	0·4	0·0
3	76	1·7	0·6	0·4	0·2
4	102	1·1	0·3	0·1	0·1
5	75	1·6	0·6	0·1	0·0
6	75	6·2	0·7	0·2	0·0
7	63	7·6	6·1	5·0	2·7
8	221	8·6	2·2	1·6	1·1
WINTER	1959–60				
1	363	0·1	0·0	0·0	0·0
2	339	0·0	0·0	0·0	0·0
3	358	0·7	0·3	0·2	0·0
4	327	0·1	0·0	0·0	0·0
5	398	0·1	0·1	0·0	0·0
6	398	1·1	0·3	0·1	0·0
7	405	1·2	0·5	0·3	0·0
8	186	13·7	4·5	2·3	0·2

TABLE 3.—*West Ham : Multi-fire Usage*

Number of Fires in Use Together	Total Time (hr)			Total Time (per cent)		
	Winter 1958–59	Summer 1958–59	Winter 1959–60	Winter 1958–59	Summer 1958–59	Winter 1959–60
1	2	3	4	5	6	7
0	1,559	3,106	1,954	38·0	75·8	44·9
1	671	539	657	16·4	13·1	15·0
2	572	195	439	14·0	4·7	10·1
3	358	135	307	8·7	3·3	7·0
4	303	73	297	7·4	1·8	6·8
5	313	45	363	7·6	1·1	8·3
6	241	7	244	5·9	0·2	5·6
7	75	0	83	1·8	0·0	1·9
8	8	0	16	0·2	0·0	0·4
Total ..	4,100	4,100	4,360	100·0	100·0	100·0

(2) TERMINATION TESTS

All continental accounts of experience with branched flues for solid fuel appliances have stressed the importance of good termination to ensure the satisfactory operation of the system. This condition was complied with both at Westminster and West Ham, but, in view of the complete success of these installations, there has sometimes been a tendency to overlook the extent to which this success has been dependent upon the good termination.

(A) THE HOLBORN INSTALLATION

A second branched-flue installation serving high-efficiency gas fires was erected at Holborn. The general layout of the flues and flue block, a 10-storey one containing 30 flats, is shown in Figures 1 and 2. There were two stacks, one for 10 flats, and another for the remaining 20 back-to-back dwellings. In each case the bottom five appliances were connected to one main flue, the next four to a second, and the top appliance was vented separately.

Although, when originally approved, the termination of the system was freely exposed, architectural modifications to the tank room prior to erection resulted in the terminals being partially shielded by a canopy. Pre-occupation experiments on the restrictor setting of the gas fires revealed intermittent downdraught on the top appliance connected to the flue serving the five lowest flats at the south side of the building. Subsequent experiments revealed intermittent downdraught on most of the fires connected to this flue, whereas very satisfactory operation was obtained with the corresponding flues at the north side of the building. Further observations, made when the wind was blowing from the opposite direction, reversed this state of affairs. Thus, downdraught was experienced either on the north or the south aspect flues, depending on the wind direction, but never on both simultaneously. This proved that the flues themselves were quite satisfactory, and that the downdraught was a function of the wind direction and terminal position.

To determine the pressure conditions in any flue, measurements were taken at a pressure-point in a plate sealed over the fireplace opening. For the purpose of the tests, the fourth-floor position was selected, i.e., the top position on the longer main flue. With the wind blowing from a direction leading to downdraught in the south aspect flue, the recorder traces shown in Figure 3 were obtained. It can be seen that the north aspect flue registered almost continuous updraught

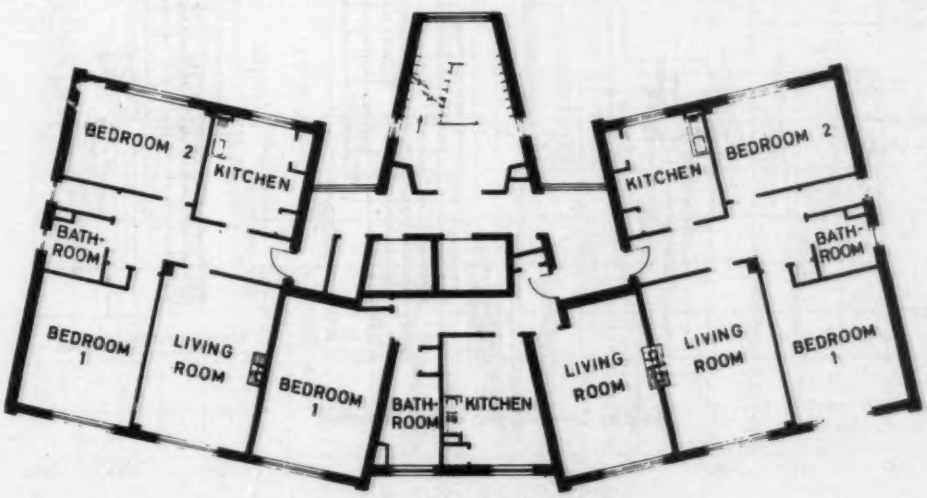


FIGURE 1.—*Holborn: First-floor Plan.*

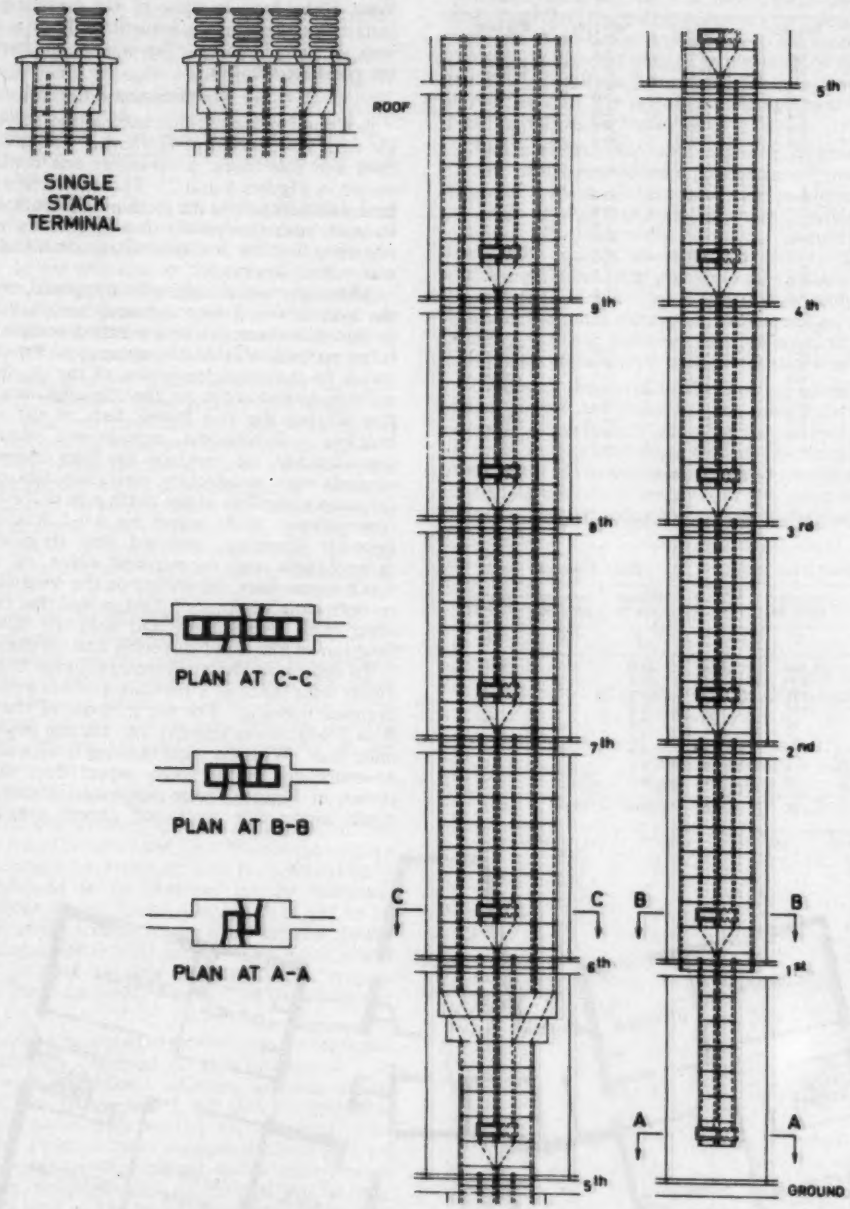


FIGURE 2.—*Holborn: Stack Elevation.*

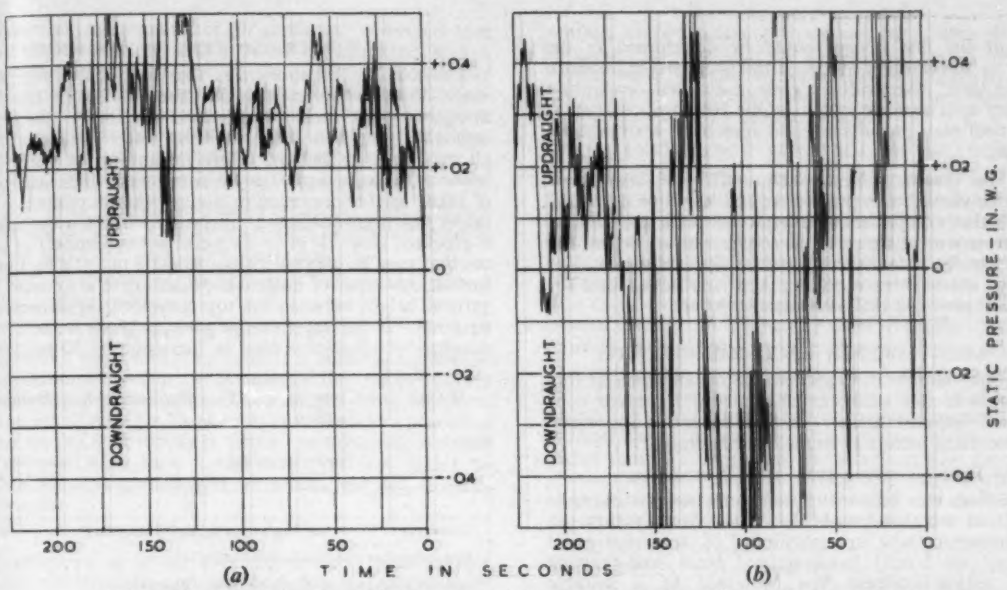


FIGURE 3.—*Holborn: Recorder Traces.* (a) *North Aspect Flue.* (b) *South Aspect Flue.*

with an average magnitude of 0·02 in. w.g. On the other hand, the south aspect flues recorded downdraught for more than 50 per cent of the time and up to 0·05 in. w.g. in magnitude.

Tests were then carried out with the termination modified. The terminal rings and top cap were first removed, with the result that the downdraught was increased as shown in Figure 4. The top of the flue was then raised by the addition of 6 ft of aluminium ducting of the same cross-sectional area as the flue, so that the termination was now level with the top of the canopy. No terminal was fitted on to the extension because of the limited stability of the structure. It can be seen from Figure 4 that this modification virtually eliminated the downdraught, and it appears certain that, with the additional thermal head available when appliances are alight and the assistance of the extraction effect of the terminals, downdraught will be completely eliminated.

(B) Laboratory Experiments

Whilst the experiments at Holborn showed that downdraughts may be eliminated by modification to the stacks after the building has been completed, it is obviously better to specify the correct terminal siting at the stage when the flue system and building are designed. It would, therefore, be very valuable if the minimum stack height for satisfactory

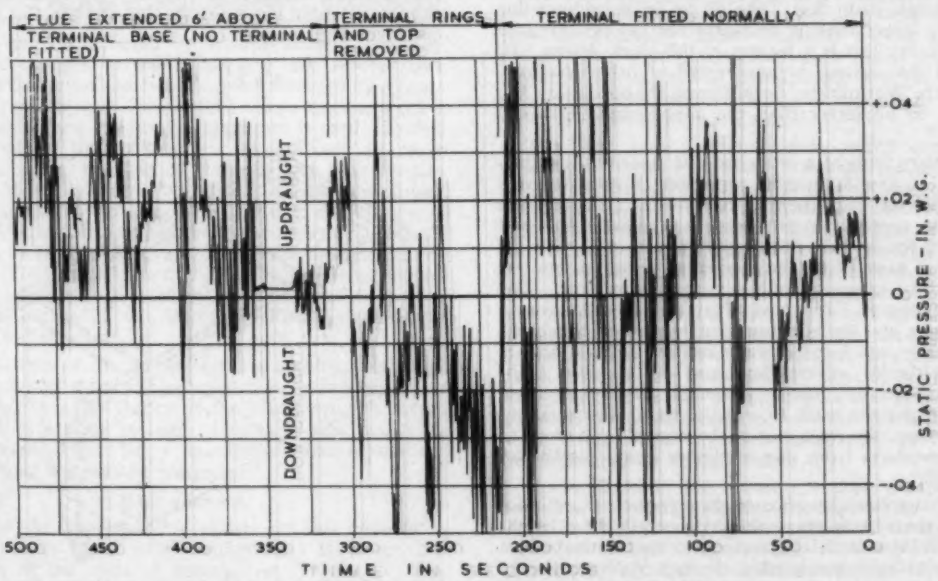


FIGURE 4.—*Holborn: Recorder Traces After Modification.*

operation of the flue system could be determined in the laboratory by subjecting a model of the proposed building to wind-tunnel tests. Appendix 2 gives a detailed description of laboratory tests on scale models of the Holborn installation and of the roof plan ; results in good agreement with practice are recorded.

Clearly, the results of tests with models of large scale ratios must be viewed with great care, and it will be necessary to obtain further comparisons between full-scale and laboratory-scale tests with different roof configurations before the techniques can be established conclusively. However, the results so far are very encouraging, and it is hoped that the technique will prove of real assistance in future.

(3) CURRENT DESIGN RECOMMENDATIONS

Although the number of branched-flue installations serving gas appliances is still small, experience has increased confidence in their use still further. It therefore seems opportune to review the main factors in branched flue design.

(A) FLUE CONSTRUCTION AND DIMENSIONS

Branched flues can be constructed from pre-cast concrete blocks or from asbestos-cement flue pipe. Since with a tall building, however, there is a possibility of condensation in the flue, pre-cast blocks manufactured from acid-resisting cement or asbestos-cement flue protected by a suitable coating are to be preferred. An acid-resisting jointing compound should also be used.

The dimensions of a branched-flue system are dependent upon the number, rating and types of appliance connected to the main duct, and their diversity of use. With pre-cast blocks, however, it has been convenient up to the present to standardize on a particular flue section and to specify limits for the numbers of appliances that may be connected. The dimensions used in existing installations consist of an 8 in. × 8 in. main flue and an 8 in. × 6 in. subsidiary flue, the two sections being combined in a single block, 12 in. high, for easy construction. A block having the same subsidiary flue dimensions, but with a main section of 8 in. × 12 in., is also available, which enables more appliances to be connected to a single main flue. The 48 sq. in. subsidiary flue is appreciably larger than is necessary for the performance of the system, but this is a feature of the block design. If, however, the flue system is constructed in other material, as in one of the Westminster installations, the subsidiary flue section need be no larger than the appropriate individual flue.

The subsidiary limb of a branched-flue system has a two-fold purpose. Under favourable conditions, it provides each appliance with its own thermal head, which ensures the clearance of its combustion products into the main duct and thus, provided the latter is of adequate size to deal with the total volume of gases of all the appliances in use at any one time, satisfactory operation of the system is ensured. The height of the branch limb must, therefore, be sufficient to ensure clearance, and the recommended figures, which include a factor of safety, are 6 ft for water heaters and air heaters (which are virtually self-clearing) and 10 ft when high-resistance gas fires are used. Secondly, if unfavourable conditions are present, such as would lead to downdraught in any flue system, the resistance of the branch limb tends to prevent the products from one appliance being discharged into another flat.

To ensure complete clearance of the uppermost appliance connected to the system, there should generally be a height of at least 20 ft between this appliance and the terminal. This requirement normally necessitates the top appliance being vented separately, although not invariably, e.g., where the top dwelling is a maisonnette.

(B) NUMBER AND TYPES OF APPLIANCES

The number of appliances that may be connected to a single main flue varies with the rating and likely usage of the appliances. It must be assumed that with space heating appliances and continuous-burning water heating appliances all may be used together ; with instantaneous water heaters, however, a usage factor can be introduced, since the likelihood of many appliances being in use together is remote. Table 4 below has been published previously,[7] but, for completeness, is repeated here. It gives the permissible numbers of appliances that may be connected to a single 8 in. × 8 in. main duct for various types of heater, provided there is at least 20 ft of vertical height between the top connected appliance and the terminal. If the larger size of pre-cast block is used, then the numbers of appliances may be increased by 50 per cent.

TABLE 4.—*Connexion of Gas Appliances to a Branched-flue System*

Type of Appliance	Maximum Number of Appliances
1	2
Circulator or Warm Air Heater (up to 30,000 B.t.u./hr)	10
Convector Fire with Controlled Ventilation	5 or 6*
Instantaneous Bath or Multipoint Water Heater ..	10
Central Heating Boiler (up to 50,000 B.t.u./hr output) ..	9

* In the case of the gas fire, the above figure may be increased to 6 when the vertical height of flue between the top appliance and the terminal exceeds 40 ft.

When the number of storeys exceeds the figures quoted in Table 4, a second main duct must be used. Thus, for a 12-storey block serving controlled ventilation fires, the recommended arrangement would vent the bottom six appliances into one main duct, the next five into a second, and the top appliance separately.

Where two appliances are fitted in the same room, it is permissible to connect them both into the same main flue, provided each is equipped with its own branch limb. Figure 5 shows a suitable block design that enables this to be carried out in a simple manner.

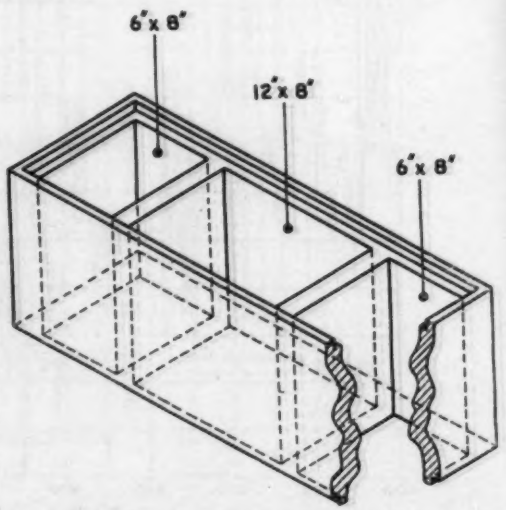


FIGURE 5.—*Branched Flues: Block Design for Connexion of Two Appliances in One Room.*

The essential requirements of an appliance connected to a branched-flue system are that it must be equipped with a flame-failure device to obviate any possibility of hazard due to unburnt gas entering the main duct ; and that the flow of products and air through the appliance should be reasonably controlled under normal operating conditions. If this is not so, the stability of the system may be upset.

Appliances that satisfy these requirements are :

(i) Any water heating appliance equipped with a flame-failure device. This includes central heating boilers.

(ii) Any approved warm-air heating appliance.

(iii) Any convector gas fire that can be supplied with a flame-failure device.

(C) Siting of Appliances

Since, with a branched flue, there is a connexion between rooms in different dwellings, it is essential that the possibility of adverse pressure distribution occurring should be kept to a minimum. For this reason, appliances connected to a branched flue must be fitted in rooms in which the windows or other means of ventilation have a similar aspect (i.e., likely to experience the same atmospheric pressure) and not in back-to-back rooms.

(D) Terminations

The importance of sound termination for a branched flue cannot be overstressed, and has been amply demonstrated by the tests at Holborn. It is important that an efficient terminal should be fitted, and it is further essential that the position of the termination should be freely exposed, well clear of any obstacles, and above the ridge of a pitched roof or at least 3 ft above the parapet of a flat roof.

(E) Flue Dampers and Appliance Restrictors

Provided each appliance is equipped with a subsidiary flue of adequate height, the performance of a branched flue is limited by the capacity of the main flue, where, for optimum conditions, the thermal head must be utilized in the most efficient manner.

In general, although an appliance may not be in use, the thermal head in the main flue resulting from other appliances in use will induce air flow through the former. If this occurs, the pull will not be utilized to the best advantage. Improved performance can be achieved by incorporating a thermally operated flue damper in the subsidiary limb above each appliance. This device consists of a plate actuated by a heat-sensitive coil, which closes or partially closes the flue section when cold, and opens it when the appliance is used. In this way, the available thermal head is applied only to those appliances in use. The use of these devices may be less important where continuous-burning appliances are fitted, since the flue must, in any case, be of adequate size to remove the products from all appliances in use together ; it will, therefore, be more than adequate when some heaters are not in operation. Where, however, a usage factor is introduced in the design because the appliances will not all be in use together, the fitting of the dampers should significantly improve the performance.

The adjustment of the restrictor on a gas fire connected to a branched-flue system raises particular problems, since each appliance has, in theory, some effect on the others connected to the same system. However, this matter is under investigation and it is anticipated that a uniform restrictor setting may well be adequate.

(F) Regulations

The use of the branched-flue system in this country is still prohibited by many local regulations. However, the revised draft of the code of practice on " Flues for Gas Appliances ", now under discussion, regards this method of venting gas appliances as good practice, although it may be necessary for a waiver of the regulations to be obtained. Amendments to the London Gas Regulations are under discussion at the present time, with the same object in view, and have reached an advanced stage.

(4) EXPERIENCE WITH SOLID-FUEL SYSTEMS

As a result of the extensive experience[8] with branched flues for solid-fuel appliances on the Continent over the past 25 years, the use of similar installations in this country has progressed at an appreciably greater rate than the development of the system for gas appliances. At least 14 installations, serving some 420 dwellings, are known to be operating. The installations are in blocks of flats between four and 11 storeys in height and generally serve openable stoves, though, in a few cases, open fires have been used

Although the problems are not identical, it has been felt that any dissatisfaction experienced with solid-fuel systems may act as useful pointers to shortcomings in gas installations. Alternatively, the success of solid-fuel systems could give added confidence in the use of the system with gas appliances. It was, therefore, decided to keep a number of the solid-fuel installations under observation with a view to detecting any dissatisfaction with branched flues.

The first system serving solid-fuel appliances in this country was erected at Peckham and was the subject of pre-occupation tests by investigators from the Building Research Station. They reported[9] that their tests showed the system to be generally satisfactory with open-type appliances, but was better with closed stoves ; however, they considered a trial period with the open grates to be justified. After some 18 months, tenants were interviewed to obtain their experiences with the system, and a number of reports of spillage were received. The complaints were not universal, however, and were confined to one end of the building, suggesting that troubles were probably aggravated by the position of the terminal in relation to the prevailing wind conditions. A similar investigation of an early installation at Brixton, where the appliances consisted of closed stoves, produced no complaints whatever of spillage.

Between the end of 1959 and the summer of 1960, five further installations in the London area were visited with a view to obtaining users' reactions to the system. The tenants who were interviewed were asked questions concerning the incidence of downdraught and the transmission of sounds. The installation details and results of the interviews are summarized in Table 5.

It is clear from these interviews, which confirm the experience obtained over many years on the Continent, that there is an appreciable difference between the performance of branched-flue systems with openable stoves connected to them and having low rates of flow and that of similar flues with open-type appliances having unrestricted flows. The Wanstead and East Ham installations consisted solely of openable stoves and received the minimum proportion of adverse comments. At Shoreditch and Bethnal Green, a mixed collection of appliances had been used, and, although the proportion of adverse comments was no higher than might be expected from tenants using a conventional flue installation, it seems probable that the presence of open grates had an adverse effect on the performance of the installations. The open-fire installation at Chertsey was clearly inferior to all the others.

The explanation put forward is that, irrespective of the heat input, there is a limit to the capacity of the main flue. Open fires require a large throughput of air and are of low resistance to flow. Thus, when such appliances are connected to a common flue the dimensions of this must be adequate to convey the total volume of air and products

TABLE 5.—*Solid-fuel Branched-flue Installations.*

Location	Number of Storeys	Number of Dwellings	Appliances	Connexion of Appliances	Subsidiary Lift (ft)	No. of Tenants Interviewed	Comments:	
							On Downdraught	On Noise Transmission
1	2	3	4	5	6	7	8	9
Wanstead	8	32	Closed stoves.	4–3–1	12	10	One report of very occasional puffs.	None
East Ham	8	44	Closed stoves.	4–3–1	10 to 12	24	Three reports of occasional spillage.	None
Bethnal Green	11	128	Closed stoves and a few open fires.	5–1 (Maisonettes)	25	83	Four cases of occasional spillage when appliances in use. Three (all open fires) of downdraught with fires not in use.	None
Shoreditch	6	24	Closed stoves and a few open fires.	4–1–1	8	13	Two cases only.	None
Chertsey	4	24	Open fires.	5–1	8 to 9	18	10 reports of downdraught.	None

from all the appliances when operating together. Under these conditions, it is likely that the flue will be operating at or near its maximum capacity, and if it should be temporarily overloaded then spillage will occur, generally from the uppermost appliance since this has the smallest total pull. Similarly, fluctuations in the pressure difference between the room and the terminal will have a more significant effect on the flow in the flue when open fires are used, again because of the low resistance. With appliances of the closed type having inherent in their design a considerably higher resistance, these problems are not encountered.

The conclusions drawn from the interviews are that appliances having low and controlled flows are the most suitable for fixing to a branched-flue system. Thus a gas appliance will, in general, be more suitable than a solid-fuel appliance, and a water heater or air heater better than a gas fire, although, if the latter is of modern design and adequately restricted, this will also be satisfactory, as has been proved at West Ham.

IV THE SE-DUCT SYSTEM

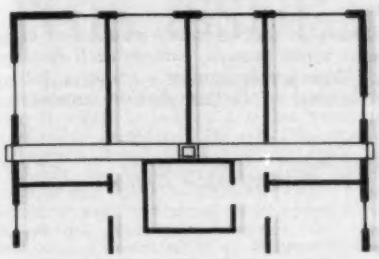
Since 1956[5], more than 300 Se-Ducts have either been constructed or are under construction in this country and abroad to serve some 5,000 dwellings. The earliest installations have afforded the means for verifying the predictions of the behaviour of the system and the validity of certain design assumptions that were made at that time.

Furthermore, much experience has been gained in dealing with practical problems that have arisen both in the construction of installations and in the design of appliances. It was realized, during the experimental investigations of the system, that certain points could be resolved only by observations of systems in blocks of occupied dwellings, as quantitative assessment of the effect concerned depended on the diversity of usage of the appliances and climatic conditions.

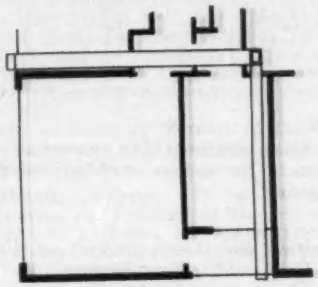
Six installations were selected for carrying out observations. The relevant particulars of the Se-Duct design and the factors

TABLE 6.—*Se-Ducts Characteristics of the Installations Examined.*

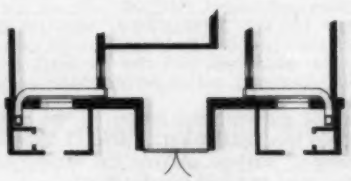
Ref.	Installation	Date Occupied	Number of Storeys	Vertical duct:		Number of Flats	Appliances Connected	Air Inlets	Measurements	Period of Observation
				Height (ft)	Size					
1	2	3	4	5	6	7	8	9	10	11
a	Gateshead	Nov., 1958	10	93	2	160	10 Water Heaters 10 Drying Cabinets	2 inlets; opposite aspects	Carbon dioxide concentration. Velocity up and down in duct. Velocity in one horizontal duct. Temperature inside and outside top. Usage of appliances.	Pre-occupation, and continuous during occupation.
b	Crawley	Dec., 1958	3	34	1	86	3 Water Heaters	Neutral area	Carbon dioxide concentration. Velocity up and down in duct.	Pre-occupation only.
c	Harlow	July, 1959	4	39	2	16	4 Air Heaters 4 Water Heaters	2 inlets; opposite aspects	Carbon dioxide concentration.	Pre-occupation only.
d	Harlow	April, 1960	12	108	3	46	12 Air Heaters 12 Water Heaters	Single inlet; shielded position	Carbon dioxide concentration. Usage of appliances.	Pre-occupation, and will be continuous during occupation.
e	Islington	July, 1959	10	95	3	80	20 Water Heaters back-to-back	2 inlets; opposite aspects	Carbon dioxide concentration. Usage of appliances.	Pre-occupation, and continuous during occupation.
f	Willesden	June, 1960	12	103	3	72	12 Water Heaters	2 inlets; adjacent aspects	Carbon dioxide concentration. Velocity up and down in duct. Usage of appliances.	Pre-occupation, and will be continuous during occupation.



(a) *Straight Through.*



(b) *Right-angle.*



(c) *Neutral Zone.*

FIGURE 6.—*Se-Ducts: Base Arrangements.*

examined are set out in Table 6, and the base duct arrangements are shown in Figure 6. The cross-sectional areas of the ducts were calculated by methods developed from theoretical considerations [10] following experimental observations on the performance of a system approximately 50 ft high.[5] The data obtained are summarized in sub-sections (1) and (2) below. The factors that underly the observed performance are considered in sub-sections (3), and, from this analysis, recommendations are made on the design of the system in sub-section (4). Sub-section (5) deals with problems and experiences in the field.

(1) MEASUREMENTS PRIOR TO OCCUPATION

Measurements of the concentration of carbon dioxide in the duct air were made with various combinations of appliances in operation in order to confirm predictions for taller ducts. It was assumed that, during occupation, up to one-third of the water heaters and all of the space heaters might be in use simultaneously, and this combination was included in the experiments. Observations were also made of the performance of the appliances.

In all cases, the concentration of carbon dioxide in the air in the duct was measured at the top of the duct, and appliances are numbered in ascending order, No. 1 being the lowest on the duct.

(a) *Gateshead*

For this installation, the temperature of the air in the duct above the top heater was also measured. Table 7 summarizes results observed and calculated with various water heaters in operation. At the time these tests were carried out, the room-sealing of the drying cabinets was not satisfactory and so, for the purpose of the tests, the connexions from the cabinets to the duct were sealed. Prior to operating the appliances, the flow conditions in the duct were observed; these are appended as a footnote to Table 7.

Although, during the tests, the wind speed was low, nevertheless, as shown later, air may have been entering the system through both inlets, or through one inlet only. Two predicted carbon dioxide values have, therefore, been calculated, and either of the values, or, indeed, an intermediate value may have applied during the tests. The predicted temperature rise values in Table 7 apply for air entry through both inlets; the corresponding values for air entry from one inlet may be deduced from the appropriate predicted concentrations of carbon dioxide. These predicted carbon dioxide and temperature rise values take into account the initial flow conditions and were calculated by the methods outlined in Appendix 5.

During the tests, very slight elongation of the flames of the upper water heater burners occurred when three heaters were in use simultaneously, and the effect became more marked with a greater number of heaters in use.

TABLE 7.—*Gateshead: Concentrations of Carbon Dioxide produced by Water Heaters.*

Water Heaters in Operation	Measured CO_2 (per cent)	Predicted CO_2 (per cent)		Temperature Rise (°F)	
		Two-inlet Entry	Single-inlet Entry	Observed	Predicted
1	2	3	4	5	6
No. 10*	1·4	1·2	1·3	71	75
Nos. 10 to 9 ..	1·7	1·4	1·6	78	86
Nos. 10 to 7 ..	1·9	1·8	1·9	94	103
Nos. 10 to 5 ..	2·2	2·2	2·4	119	110
Nos. 10 to 3 ..	2·7	2·4	2·7	158	116‡
Nos. 10 to 1 ..	2·9	2·8	3·0	166	123‡
No. 10†	1·1	1·0	1·1	—	63
Nos. 10, 9 ..	1·5	1·3	1·5	—	80
Nos. 10, 9, 8 ..	1·9	1·6	1·8	—	95
No. 1	0·6	0·5	0·5	—	11
Nos. 1, 2 ..	0·9	0·7	0·9	—	20
Nos. 1, 2, 3 ..	1·2	1·0	1·2	—	28

*Downward flow, 0 to 1 ft/sec.

†Upward flow, 1 to 1·4 ft/sec.

‡Part of the discrepancy is due to a rise in temperature of the wall of the duct, estimated to be approximately 30°F, which occurred during the period of 90 min. when the upper heaters were in operation immediately prior to operating the lower heaters.

Observations were made on the performance of the drying cabinets when these alone were in use, and again when water heaters were in use. Measurements were made of drying efficiency with nine of the 10 drying cabinets loaded with lengths of cloth of average dry weight 8¼ lb, and with a water content, after hand wringing, of 14 lb. The efficiency of the individual cabinets was found to be independent of the distance of the cabinet from the top of the duct, and for every cabinet the efficiency was satisfactory with a mean value of 0·19 lb/500 B.t.u. After the cabinets had been in operation for 1 hr, a film of condensation was present in the upper 5 ft of the duct, but this was insufficient to form droplets, and dried out after a further period of approximately 45 min. The external air temperature during this test was

56°F, and the concentration of carbon dioxide during the 2 hr drying period was 0·3 per cent. The efficiency of No. 1 drying cabinet when three water heaters were in operation above it for the whole of the drying period was unchanged, and similar results were obtained for No. 10 drying cabinet when four water heaters were in operation below.

(b) *Crawley*

Measured and theoretical values of the concentration of carbon dioxide are summarized in Table 8.

TABLE 8.—*Crawley : Concentrations of Carbon Dioxide Produced by Water Heaters.*

Water Heater	Measured CO_2 (per cent)	Theoretical CO_2 (per cent)
1	2	3
No. 1	0·7	0·8
No. 1, 2	1·3	1·5
No. 1, 2, 3	—	2·1

(c) *Harlow (Four-storey Block)*

Measured and theoretical values of the concentration of carbon dioxide for individual water heaters and air heaters, and for combinations of appliances, are given in Table 9.

TABLE 9.—*Harlow (Four-storey Block) : Concentrations of Carbon Dioxide Produced by Water Heaters and Air Heaters.*

Appliances in Operation	Measured CO_2 (per cent)	Theoretical CO_2 (per cent)
1	2	3
No. 1 Water Heater	0·7	0·7
No. 4 Water Heater	1·0	1·4
No. 1 to 4 Water Heaters ..	2·2	2·1
No. 1 Air Heater	0·3	0·3
No. 4 Air Heater	0·4	0·4
No. 1 to 4 Air Heaters ..	0·8	0·8
No. 1 to 4 Air Heaters .. / No. 2 to 4 Water Heaters ..	2·0	2·1

(d) *Harlow (12-storey Block)*

As with the four-storey block, Table 10 gives measured and theoretical concentrations of carbon dioxide for individual appliances and for various combinations, including one with all 12 water heaters functioning simultaneously.

TABLE 10.—*Harlow (12-storey Block) : Concentrations of Carbon Dioxide Produced by Water Heaters and Air Heaters.*

Appliances in Operation	Measured CO_2 (per cent)	Theoretical CO_2 (per cent)
1	2	3
No. 1 Water Heater ..	0·4	0·5
No. 1 to 6 Water Heaters ..	1·4	1·6
No. 1 to 12 Water Heaters ..	2·4	2·8
No. 1 to 12 Air Heaters ..	0·7	1·2
No. 1 to 12 Air Heaters .. / No. 9 to 12 Water Heaters ..	1·3	2·1
No. 1 to 12 Air Heaters .. / No. 7 to 12 Water Heaters ..	1·8	2·5

(e) *Islington*

The Se-Ducts in this 10-storey installation each carry 20 instantaneous water heaters, two on each floor in back-to-back flats. These are designated A and B in Table 11, which lists measurements of carbon dioxide compared with predictions.

TABLE 11.—*Islington : Concentrations of Carbon Dioxide Produced by Water Heaters.*

Water Heaters in Operation	Measured CO_2 (per cent)	Theoretical CO_2 (per cent)
1	2	3
No. 1A, 1B	0·5	0·7
No. 1A to 5A, 1B to 5B ..	1·6	2·1
No. 8A to 10A, 8B to 10B ..	1·6	2·0
No. 1A to 5A, 7A to 8A, 1B to 7B	2·0	2·8
No. 1A to 6A	1·1	1·5
No. 5A to 10A	1·2	1·9

(f) *Willesden*

Table 12 gives measured and theoretical concentrations of carbon dioxide for various combinations of water heaters at this installation.

TABLE 12.—*Willesden : Concentrations of Carbon Dioxide Produced by Water Heaters.*

Water Heaters in Operation	Measured CO_2 (per cent)	Theoretical CO_2 (per cent)
1	2	3
No. 1 to 11	1·7	2·4
No. 3 to 5	0·8	1·0
No. 6 to 8	1·0	1·1

The effect of reducing the system to the single-inlet type was studied on this installation. Table 13 shows comparative concentrations of carbon dioxide for various combinations of appliance usage and inlet condition.

TABLE 13.—*Willesden : Effect of Inlet Openings on Concentration of Carbon Dioxide.*

Water Heaters in Operation	Both Inlets Open	North Inlet Closed	East Inlet Closed
1	2	3	4
No. 1 to 11	1·6	1·8	1·8
No. 1 to 3	0·7	0·9	1·2
No. 4 to 6	0·7	0·9	1·2
No. 7 to 9	0·8	1·1	1·3
No. 9 to 11	0·6	1·4	1·4

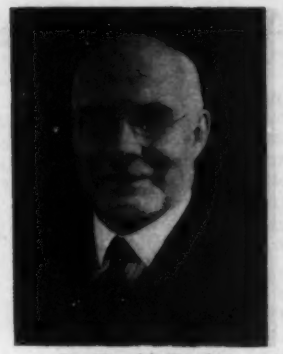
(g) *Summary*

These tables show that, over a wide range of experimental conditions, the observed values agree sufficiently closely with those predicted to justify the methods used for the calculation of thermally induced flow rates. The observations confirm also the prediction of a comparatively small rise in the concentration of carbon dioxide at the top of the duct when the upper one-third of the water heaters are in use and additional heaters are put into operation.

The simultaneous drying of a total of nearly 2 cwt of wet cloth produced negligible condensation in the duct, and the performance of the upper cabinets was not affected by the humidity of the duct air. Operation of water heaters above or below the cabinets did not affect their performance.

[*To be continued.*

IN THIS ISSUE...



Sir Harold Hartley

Duncan D. Melvin

C. H. Purkis

W. J. Bennett

J. B. Carne

T. T. White

Sir Harold Hartley was educated at Dulwich College, the University of Munich, and at Balliol College, Oxford, of which he became a fellow, tutor and lecturer in physical chemistry. He was Chairman of the Fuel Research Board from 1932 to 1947, and honorary adviser on home-produced fuels to the Ministry of Fuel and Power in 1939-47.

In the World Power Conference, he has been Chairman of the British National Committee and International Executive Council (1935 to 1950), Chairman of the First World Power Conference (1950) and President (1950 to 1956).

Sir Harold was a Director of the Gas Light and Coke Company from 1922 to 1945, and was appointed Deputy Governor of the Company in 1944. He was President of the Society of British Gas Industries in 1937-38, of The Institution of Chemical Engineers in 1951-52 and 1954-55, and of the Society of Instrument Technology in 1957.

He was elected an Honorary Member of The Institution of Gas Engineers in 1937, and was awarded its Birmingham Medal in 1958.

Duncan D. Melvin, Chairman of the Chairmen's Technical Committee, was President of The Institution of Gas Engineers in 1959-60. He was educated at Rutherglen Academy and at the Royal College of Science and Technology, Glasgow. After holding engineering positions in the gas works at Dalmarnoch and Uddingston, he became in 1933 Assistant Engineer and Manager of the Edinburgh Gas Department, being appointed Deputy Engineer and Manager in 1939. In 1946, he succeeded the late Mr. James Jamieson as Engineer and Manager at Edinburgh. He has been a full-time member of the Scottish Gas Board since 1946. He holds the Diploma of The Institution of Gas Engineers and a Silver Medal of the City and Guilds of London Institute.

C. H. Purkis was educated at Owen's School, Islington, and St. John's College, Oxford, where he obtained a first-class honours degree in Natural Science. He joined the staff of Watson House in 1936, originally in the Cooking Laboratory, and is now the Officer-in-Charge of the Water Heating Laboratory. He has been the author or co-author of several papers to the Institution since 1950, and was President of the London and Southern Junior Gas Association in 1958-59. He is also a member of several of the Institution's Codes of Practice Panels and of the *ad hoc* Committee on Electrical Bonding.

W. J. Bennett was educated at the High School for Boys, Chichester, and King's College, London, where he graduated with honours in Mechanical Engineering in 1948. By part-time study, he subsequently obtained B.Sc. and M.Sc. degrees in Mathematics in 1950 and 1957 respectively. He joined the staff of Watson House in 1948 and is now the deputy to the Officer-in-Charge of the Water Heating Laboratory. He has been co-author of a number of papers on flues, and was awarded the Institution's Gold Medal in 1959.

J. B. Carne, at the age of 19, joined the Physical Laboratory of the South Metropolitan Gas Company in 1923 as an assistant to Dr. J. S. G. Thomas (Senior Physicist), and later became assistant to Mr. Dean Chandler (Chief Technical Officer of the Company). While attending as an evening student in the Physics Department of Battersea Polytechnic, he took a B.Sc. General Degree of the University of London in 1925, and a special Physics Degree in 1927. He was appointed Head of Appliance Laboratories of the South Eastern Gas Board in 1957. He initiated the development of the gas panel system for "infra-red" processing in 1943, and the Se-Duct system for the flueing of gas appliances in multi-storey dwellings in 1954. He is the author of a number of papers on experimental investigations of subjects relevant to gas utilization.

T. T. White was born in 1924 and educated at the Roan School, Greenwich, and Imperial College of Science and Technology, University of London, where he was awarded in 1945 a degree in Physics and Mathematics with first-class honours. Until 1948, he was employed by the Telegraph Condenser Company, North Acton. Since 1948, he has worked, in the Utilization Laboratories of the South Eastern Gas Board, on the design and development of gas appliances and methods of their installation particularly in regard to flues. He is the author of two previous papers on the Se-Duct system, one of which is an analysis of the functioning of the system from theoretical considerations.

26th Autumn Research Meeting

The 26th Autumn Research Meeting of The Institution of Gas Engineers was held in The Church House, Westminster, London, S.W.1, on Tuesday and Wednesday, 15th and 16th November, 1960, under the presidency of Hugh Southworth Cheetham, Esq., M.I.Mech.E., M.I.Gas E., M.I.Chem.E., F.Inst.F., Director, Woodall-Duckham Construction Company, Limited, and of Woodall-Duckham, Limited, who occupied the chair at those sessions that were held in the Assembly Hall.

Thomas Charles Battersby, Esq., M.B.E., M.I.Mech.E., M.I.Gas E., Senior Vice-President, occupied the chair at a parallel session held in the Hoare Memorial Hall of The Church House in the afternoon of the first day of the Meeting.

The detailed programme of the Meeting was as follows :—

Tuesday, 15th November, 1960

Opening of 26th Autumn Research Meeting

ASSEMBLY HALL

9.30 a.m.

1. The Secretary (W. T. K. Braunholtz) to read the NOTICE convening the Special General Meeting of The Institution of Gas Engineers at Church House, Westminster, London, S.W.1.
2. Report of the Scrutineers of the BALLOTS for the election of Members, Associate Members and Associates.
3. Presentation and discussion of the 37th REPORT OF THE GAS EDUCATION COMMITTEE: 1959-60. (*Communication No.* 576).

10.20 a.m.

4. (*a*) Presentation of CHARLES HUNT MEMORIAL MEDALS for 1960 to :—

   Michael Joseph Tidd (London) ; Associate Membership Examination—Gas Engineering (Manufacture).

   Kenneth Frost (West Kirby) ; Associate Membership Examination—Gas Engineering (Supply).

   (*b*) To present a JAMES ARCHIBALD MACLAY MEMORIAL PRIZE for 1960 to :—

   Robert Stewart Mathers (Maryport)—Gas Technology (Supply).

10.30 a.m. to 11.15 a.m.

5. Presentation and discussion of the 21ST REPORT OF THE CHAIRMEN'S TECHNICAL COMMITTEE : 1959-60. (*Communication No.* 577).

11.15 a.m. to 12.15 p.m.

6. Presentation and discussion of Paper, " THE CHOICE OF SUBJECTS FOR RESEARCH AND DEVELOPMENT ", by Sir Harold Hartley, G.C.V.O., F.R.S., Hon.M.I.Gas E. (*Communication No.* 578).

Adjournment

12.45 p.m.

7. Autumn Research Luncheon. (By invitation).

ASSEMBLY HALL

3 p.m. to 3.50 p.m.

8. Presentation and discussion of Paper, " COMBINED TOWN GAS/FUEL OIL FLAMES FOR HEATING FERROUS METALS ", by E. A. K. Patrick, B.Sc., F.R.I.C., M.I.Gas E., M.I.Chem.E. (Officer-in-Charge), and N. G. Patel, B.Sc.(Chem.Eng.), (Chemical Engineer), Industrial Laboratory, Watson House, London Research Station, The Gas Council. (*Gas Council Research Communication GC*67).

3.50 p.m. to 4.40 p.m.

9. Presentation and discussion of Paper, " THE STABILITY OF AIR BLAST TUNNEL BURNERS ", by W. E. Francis, B.A., A.M.Inst.F., and M. L. Hoggarth, B.Sc., Midlands Research Station, The Gas Council. (*Gas Council Research Communication GC*68).

4.40 p.m. to 5.30 p.m.

10. Presentation and discussion of Paper, " The IGNITION AND CONTROL OF TUNNEL BURNERS ", by P. G. Atkinson, B.Sc., and R. A. Hancock, Dip.Tech., Grad.Inst.P., Midlands Research Station, The Gas Council. (*Gas Council Research Communication GC*69).

HOARE MEMORIAL HALL

3 p.m. to 3.50 p.m.

11. Presentation and discussion of Paper, " RADIO COMMUNICATIONS IN THE FUEL AND POWER INDUSTRIES ", by G. M. Rimmer, M.Sc.(Eng.), M.I.Mech.E., M.I.Gas E., M.I.E.E., M.Amer.I.E.E., Electrical and Mechanical Engineer, West Midlands Gas Board. (*Communication No.* 579).

3.50 p.m. to 4.40 p.m.

12. Presentation and discussion of Paper, " THE THERMODYNAMIC STUDY OF THE REFORMING OF HYDROCARBONS AND ITS APPLICATION TO AUTOTHERMIC GENERATORS ", by J. Ribesse (Engineer), and C. Van Maele (Engineer), Distrigaz, S.A., Belgium. (*Communication No.* 580).

4.40 p.m. to 5.30 p.m.

13. Presentation and discussion of Paper, " AN INVESTIGATION INTO THE COMPOSITION OF AMMONIACAL LIQUOR. III—IMPROVEMENTS IN ROUTINE ANALYSIS ", by L. Barker, B.Sc., Ph.D., A.R.I.C., and N. W. Hollingworth, B.Sc., University of Leeds. (*Gas Council Research Communication GC*70).

Adjournment

Wednesday, 16th November, 1960

ASSEMBLY HALL

9.30 a.m. to 10.30 a.m.

14. Presentation and discussion of the 51ST REPORT OF THE JOINT REFRACTORIES RESEARCH COMMITTEE : 1959-60. (*Gas Council Research Communication GC*71).

10.30 a.m. to 11.30 a.m.

15. Presentation and discussion of Paper, " SOME CONSIDERATIONS OF GAS MAKING IN TERMS OF THE NATIONAL FUEL SITUATION FOR THE NEXT 25 YEARS ", by M. W. Thring, M.A., F.Inst.P., F.Inst.F., M.I.Chem.E. (Professor of Fuel Technology and Chemical Engineering), and C. Hulse, B.Sc.(Birm.), Ph.D. (Senior Lecturer, Department of Fuel Technology and Chemical Engineering), University of Sheffield. (*Communication No.* 581).

11.30 a.m. to 12.30 p.m.

16. Presentation and discussion of Paper, "EXPERIENCES WITH BRANCHED-FLUE AND SE-DUCT SYSTEMS FOR VENTING GAS APPLIANCES", by W. J. Bennett, M.Sc., B.Sc.(Eng.), A.M.I.Gas E., and C. H. Purkis, B.A., B.Sc., M.I.Gas E., A.M.I.H.V.E., London Research Station, The Gas Council; and J. B. Carne, B.Sc., and T. T. White, B.Sc., A.R.C.S., Central Laboratories, South Eastern Gas Board. (*Gas Council Research Communication GC*72).

Adjournment

2.30 p.m. to 2.45 p.m.

17. Presentation without discussion of a REPORT ON THE GAS COUNCIL RESEARCH SCHOLARSHIPS: 1960. (*Gas Council Research Communication GC*73).

2.45 p.m. to 3.45 p.m.

18. Presentation and discussion of Paper, "THE ESTABLISHMENT OF A MARKET FOR NATURAL GAS", by Jean Dhuin (Head of Gas Department) and Louis Socrate (Head of Technical Service, Gas Department), Société Nationale des Pétroles d'Aquitaine, France. (*Communication No.* 582).

3.45 p.m. to 4.45 p.m.

19. Presentation and discussion of Paper, "AN INVESTIGATION OF TUNNEL BURNER NOISE", by J. K. Kilham, B.Sc., Ph.D., A.R.I.C., E. G. Jackson, B.Sc., Ph.D., and T. J. B. Smith, B.Sc., The Joint Research Committee of The Gas Council and the University of Leeds. (*Gas Council Research Communication GC*74).

4.45 p.m. to 5 p.m.

20. VOTE OF THANKS to :—
    - (*a*) The Gas Council.
    - (*b*) The Corporation of The Church House.
    - (*c*) The Authors of Reports and Papers.
    - (*d*) Undertakings, Organizations and Gentlemen conducting Education or Technical or Research work for the Institution or The Gas Council or providing facilities therefor.
    - (*e*) The Chairmen and Members of the Gas Education Committees, the Board of Examiners, and the Technical and Research Committees of the Institution and The Gas Council.
    - (*f*) The Scrutineers of the Ballot.
    - (*g*) The Secretary and Staff of The Institution of Gas Engineers.
    - (*h*) The Chairman.

Termination of 26th Autumn Research Meeting.

Welcome to Overseas Representatives

At Tuesday morning's session the President welcomed the following representatives and visitors from overseas :—

Monsieur R. H. Touwaide (Brussels ; General Secretary, International Gas Union, and of Association Royale des Gaziers Belges), Monsieur J. Ribesse (Brussels ; Distrigaz, S.A.), Monsieur C. Van Maele (Brussels ; Distrigaz, S.A.), Monsieur Y. Quéret (Paris ; President, Association Technique de l'Industrie du Gaz en France), Monsieur A. Lihrmann (Paris ; Secretary, Association Technique de l'Industrie du Gaz en France), Monsieur R. Liard (Paris ; Gaz de France), Monsieur J. Dhuin (Paris ; Société Nationale des Pétroles d'Aquitaine), Monsieur L. Socrate (Paris ; Société Nationale des Pétroles d'Aquitaine), Dr.-Ing. F. A. Oetken (Frankfurt ; Lurgi Gesellschaft für Warmetechnik m.b.H.), Dipl.-Ing. W. Riedel (Butzbach/Hessen ; Pintsch Bamag A.G.,) Dr.-Ing. H. Weittenhiller (Essen), Dr. Wucherer (Hollriegelskreuth ; Gesellschaft für Linde's Eismaschinen A.G.), and Mr. M. C. Tuyn (The Hague ; Bataafse Internationale Petroleum Maatschappij N.V.).

Vote of Thanks

The general vote of thanks to those concerned in the organization and conduct of the 26th Autumn Research Meeting was proposed and seconded as follows :—

Mr. L. P. Ingram, M.B.E. (Bath) :—To me falls the privilege and pleasure of proposing a sincere vote of thanks to all those organizations and individuals who have made this 26th Autumn Research Meeting not only possible, but such an outstanding success. I regret that the attendance at this stage is so small, and perhaps this may be the subject of later consideration by the hierarchy, but I know that I am expressing the view of everyone who attended during the last two days when I say that our gathering has been successful.

Our thanks are due to The Gas Council for continued support of the Institution, not only financially, which we all appreciate, but for making freely available to our members the reports and papers of its research organizations.

I am sure that I am voicing the opinions of all my colleagues when I say that we would rather meet in The Church House than anywhere else. The acoustics are good, the surroundings are good, and all the facilities are good. We are grateful to the Corporation of The Church House for again allowing us its use.

To the authors of reports and papers, to undertakings, organizations and gentlemen conducting educational, technical or research work for the Institution or The Gas Council, or providing facilities therefor, and to the chairmen and members of the Gas Education Committees, the Board of Examiners, and the technical and research committees of the Institution and of The Gas Council, we give especial thanks for the vast amount of work and investigation that they have devoted to the service of the gas industry and, hence, to this Institution.

We thank the scrutineers of the ballot for their very necessary work behind the scenes.

To our indefatigable secretary, Dr. W. T. K. Braunholtz, O.B.E., and his staff, we tender our sincere thanks for what we have come to expect twice a year—a highly successful series of Meetings, to no small extent due to their efficient organization and forethought.

Finally, to our President, who, as chairman of this Meeting, has scored his first major success in his year of office, we say that we are grateful for his wise and friendly guidance, and wish him continued good health and happiness during the remainder of his term. Many of us have welcomed him at meetings of our district sections, and from these and the Meeting now concluding we know that the affairs of our Institution are in very good hands.

Dr. W. Davidson (London) :—It is my privilege to second the vote of thanks to all who have contributed to the success of our Autumn Research Meeting. Mention has already been made of the success that has attended the researches of The Gas Council, and the promise of cheaper production and more effective utilization. I think it would not be out of place for me to include in this vote of thanks the paper, "Space and Water Heating Equipment in Houses and Flats", given by Mr. W. H. Welch to the Public Works and Municipal Services Congress, at which our President took the chair, and which many of our members attended. That paper showed clearly that gas, because of its flexibility and efficiency of operation, could provide a high standard of comfort and water-heating in flats and houses at prices, both

as regards capital and operating costs, that are competitive with those of other fuels.

The importance of the flexibility of gas is not fully understood or recognized by many heating engineers, and one has only to study the Institution of Heating and Ventilation Engineers publication "Central Heating in Our Homes" to appreciate this point.

I am pleased to learn that The Gas Council, this heating season, is making a special study of different types of heating installation, including the comfort standards obtained, the operating costs, and so on. I trust that the Council will work closely with the Building Research Station, with the Heating and Ventilating Research Association, and other bodies, so that there will be a wider acceptance of the results.

I should like to offer a word of thanks to The Gas Council for the assistance that it has given to all appliance makers so far as development and application are concerned.

The vote of thanks was carried by acclamation.

The reports and papers presented at the Meeting, together with appropriate discussions and written replies thereto, will be reproduced in this and subsequent issues of the Institution *Journal*.

26th Autumn Research Luncheon

The 26th Autumn Research Luncheon was held at the Savoy Hotel, London, on the opening day of the Meeting, Tuesday, 15th November, 1960. The President (Hugh S. Cheetham, Esq., M.I.Mech.E., M.I.Gas E., M.I.Chem.E.) was in the chair, supported by the Senior and Junior Vice-Presidents and other members of Council, and by a large number of distinguished guests, the principal of whom was Sir Alexander Fleck, K.B.E., D.Sc., F.R.S., Chairman, Ministry of Power Advisory Council on Research and Development.

Among those who accepted invitations were the following:—

N. F. Astbury, Esq., M.A., Sc.D., Director of Research, British Ceramic Research Association; D. E. Baird, Esq., M.A., T.D., Director, British Coking Industry Association; Dr. Reginald Bennett, M.P., Chairman, Parliamentary and Scientific Committee; R. N. Bruce, Esq., O.B.E., T.D., Chairman, South Eastern Gas Board, Member Research Committee, The Gas Council; J. S. Carter, Esq., C.B.E., Ph.D., M.Sc., Chief Alkali Inspector, Ministry of Housing and Local Government; C. M. Cawley, Esq., C.B.E., D.Sc., Chief Scientist, Ministry of Power; C. H. Chester, Esq., C.B.E., Chairman, South Western Gas Board, Past President, The Institution of Gas Engineers; R. K. Christy, Esq., Deputy Chief Inspector of Factories, Ministry of Labour; F. J. Dent, Esq., O.B.E., D.Sc., Ph.D., Director, Midlands Research Station, The Gas Council; G. le B. Diamond, Esq., C.B.E., Chairman, West Midlands Gas Board, Chairman, Gas Works Effluents Committee, The Institution of Gas Engineers; E. R. Dinsmore, Esq., Principal, Brooklands Technical College; E. J. C. Dixon, Esq., B.Sc., Controller of Gas Standards, Ministry of Power; M. B. Donald, Esq., M.Sc., Ramsay Memorial Professor of Chemical Engineering, University College, London; J. H. Dyde, Esq., O.B.E., M.Sc., Chairman, Eastern Gas Board, Past President, The Institution of Gas Engineers; R. S. Edwards, Esq., Ph.D., B.Sc., Chairman, North Eastern Gas Board; S. J. Emerson, Esq., M.Eng., Senior Electrical Inspector, Ministry of Labour; Martin Flett, Esq., C.B., Deputy Secretary, Ministry of Power; Professor F. H. Garner, O.B.E., Ph.D., Honorary Member, The Institution of Gas Engineers, Member, Gas Council Research Committee; A. D. Graham, Esq., B.A., Head of the Department of Technology, City and Guilds of London Institute; Sir Harold Hartley, G.C.V.O., C.B.E., M.C., M.A., F.R.S., Honorary Member, The Institution of Gas Engineers, author of paper; J. A. Hudson, Esq., Assistant Secretary, Ministry of Education; W. K. Hutchison, Esq., C.B.E., B.A., B.Sc., Deputy Chairman, The Gas Council, Past President, The Institution of Gas Engineers; R. S. Johnson, Esq., M.B.E., T.D., M.A., LL.B., Chairman, East Midlands Gas Board; Sir Henry Jones, M.B.E., M.A., Chairman, The Gas Council, Past President, The Institution of Gas Engineers; W. Idris Jones, Esq., C.B.E., Ph.D., Director-General of Research, National Coal Board; A. Key, Esq., D.Sc., Ph.D., Honorary Member, The Institution of Gas Engineers, Senior Chemical Inspector, Ministry of Housing and Local Government; Col. Geoffrey Kitson, O.B.E., Chairman, Livesey Professorship Committee, University of Leeds; C. H. Leach, Esq., M.A., Chairman, Southern Gas Board; G. W. Lee, Esq., M.Sc., Director, British Coke Research Association; Monsieur R. Liard, Gaz de France; Monsieur A. Lihrmann, Secretary, Association Technique de l'Industrie du Gaz en France; W. A. Macfarlane, Esq., C.B.E., B.A., B.Sc., Ph.D., President, The Institute of Fuel, Managing Director, National Industrial Fuel Efficiency Service; A. G. McLellan, Esq., J.P., B.Sc., President, The Institution of Water Engineers; D. D. Melvin, Esq., Member, Scottish Gas Board, Past President, The Institution of Gas Engineers; M. Milne-Watson, Esq., C.B.E., B.A., Chairman, North Thames Gas Board; R. J. Morley, Esq., B.Sc., Ph.D., Director of Carbonization, National Coal Board; Sir Charles Morris, M.A., Vice-Chancellor, University of Leeds; A. H. Norris, Esq., Assistant Secretary, Gas Division, Ministry of Power; Dr.-Ing. F. A. Oetken (Germany); Lt.-Comdr. Christopher Powell, R.N., Secretary, Parliamentary and Scientific Committee; D. D. Pratt, Esq., O.B.E., Ph.D., Director, Chemical Research Laboratory; Sir Dennis Proctor, K.C.B., M.A., Permanent Secretary, Ministry of Power; L. C. C. Rayner, B.Sc.(Eng.), President, The Institution of Heating and Ventilating Engineers; Monsieur J. Ribesse, author of paper; J. E. Richardson, Ph.D., B.Eng., President, Association of Principals of Technical Institutions, Secretary, Association of Technical Institutions; Dipl-Ing. W. Riedel (Germany); A. L. Roberts, Esq., B.Sc., Ph.D., Livesey Professor, University of Leeds, Honorary Member, The Institution of Gas Engineers; Sir Robert Robinson, O.M., F.R.S., Honorary Member, The Institution of Gas Engineers, Member, Gas Council Research Committee; Professor O. A. Saunders, M.A., D.Sc.(Eng.), President, The Institution of Mechanical Engineers, Dean, City and Guilds College, London; Sir Harold Smith, K.B.E., D.L., LL.D., Past President, The Institution of Gas Engineers; Monsieur L. Socrate, author of paper; Monsieur R. H. Touwaide, Honorary Member, The Institution of Gas Engineers, General Secretary, International Gas Union; D. T. A. Townend, Esq., C.B.E., D.Sc., Honorary Member, The Institution of Gas Engineers, Director-General, British Coal Utilisation Research Association; Mr. M. C. Tuyn (The Netherlands); Monsieur C. Van Maele, author of paper; H. J. Victory, Esq., B.Sc., Immediate Past President The Coke Oven Managers' Association; Dr.-Ing. H. Weittenhiller (Germany); D. P. Welman, Esq., Chairman, North Western Gas Board; Dr.-Ing. J. Wucherer (Germany); A. H. A. Wynn, Esq., M.A., Scientific Member, National Coal Board.

The Loyal Toasts having been duly honoured, the **President**, in proposing the toast " The Guests ", said:—

In 1963, The Institution of Gas Engineers will be 100 years old. By comparison, this Autumn Research Meeting of ours is much younger. It was inaugurated only 31 years ago and, as will have been noticed from the programme, this is only the 26th Meeting that has been held, having regard to the interval during the war years.

During this comparatively short period, however, our Autumn Research Meetings have come to be regarded by us as a very important part of our activities. Perhaps, for the benefit of our guests, I should explain that during our Autumn Research Meeting, we review in particular our progress in research and development. I refer not only to gas-making processes and plants, but to the whole of the techniques involved in the production, distribution and utilization of gas. We review also our educational activities and the progress of those men to whom we have awarded research scholarships. As I have said, we regard this Meeting as of very considerable importance.

This luncheon, which is an essential part of our research activities, is a special pleasure to us. It is an occasion when we have as our guests distinguished people associated with science, education, the Civil Service and public life. I shall refer later to some of our guests by name, but I should like all of them to know that the cordiality of my welcome extends to everyone present. We are delighted that you are all able to be with us today.

It is, I believe, no exaggeration to say that research in the gas industry—as in other industries—is of the greatest possible importance today. We often hear it said that we are in a changing world and that the wind of change is blowing in various directions. In fact, the wind of change is blowing as hard or harder in the gas industry than in other industries. We are being called upon to use new feedstocks, by which I mean gas-making materials, of which we have not previously had experience. We are developing new processes and plants to utilize those feedstocks. We are developing various other techniques in connexion with the distribution of gas and its utilization, all with a view, I may say, to meeting the rapidly changing pattern of consumer demand for fuel. The requirements of our consumers are changing quite rapidly in these days.

As I have said, we review on this occasion our various research projects, which are under the direction of Sir Henry Jones and the Gas Council Research Committee. Many of those projects at our various research stations have not at this date reached the stage when it is appropriate to issue Communications. Some of these research projects, as will be understood, require a long period before it is possible to reach finality—and by " finality " I mean the stage at which a particular process may be ripe for commercial development.

I think that Sir Henry would, however, like me to assure you that, although at this particular Research Meeting the number of papers presented that deal exclusively with research at the research stations is not particularly numerous, the fact is that research is proceeding with a sense of urgency, and I hope that before long we shall be able to publish further papers that will show the value of the work being done.

Now, I want to refer to those people who have contributed the papers that we have received this morning and those that we shall receive in the course of our Meeting. We are most grateful to them for all the work they have done to produce these papers.

We have had an excellent paper presented by Sir Harold Hartley, and I would say particularly that we are grateful to him for having stimulated our thoughts. (*Applause.*) He suggested that the main purpose of his paper was to give us something into which we might introduce our teeth. How he feels about that as a result of the discussion I am not very sure, but it may be that in due course he will tell us.

We are also very fortunate in having, as is customary at our Autumn Research Meeting, a number of overseas guests. I would refer particularly to Monsieur Ribesse, from Belgium, and to Monsieur Van Maele, also from Belgium, and to Monsieur Dhuin and Monsieur Socrate, from France. (*Applause.*) These four gentlemen are the authors of papers that they are to present at this Meeting. It is a particular pleasure to us when our friends from overseas come to our Meetings and provide us with papers giving us an overall picture of the techniques being developed in their particular countries.

We have also with us today Monsieur Touwaide, the General Secretary of the International Gas Union and also of the Royal Belgian Gas Association. (*Applause.*) We are always delighted to see Monsieur Touwaide, and those of us who are in the gas industry appreciate very much all the work he does for the International Gas Union. We have also Monsieur Lihrmann, of Association Technique de l'Industrie du Gaz en France, and Monsieur Liard, of Gaz de France. (*Applause.*) We welcome them.

From Germany, we have a number of guests, to one of whom I should like in particular to refer. In this country, we are much interested today in the use of our own indigenous fuel in high-pressure gasification, and we have turned our attention to the Lurgi process. In Western Germany there is a Lurgi plant, at Essen, that was built under the direction, and is still under the control, of Dr. Weittenhiller. A number of members of our Institution have sought opportunities of seeing that plant and having discussions with Dr. Weittenhiller. He has never failed us. At all times, he has shown himself willing to receive us and to discuss our problems. I should like very much to take this opportunity of thanking him for all the kindness we have received at his hands. (*Applause.*)

We have also with us Dr. Oetken, (Chairman of the Lurgi Company), and Dr. Riedel, of the Pintsch Bamag Company, who have been associated with the building of various ancillary plants in this country, and Dr. Wucherer, of the Linde Oxygen Company. We welcome them here today and we are delighted to have them all with us. (*Applause.*)

At the Isle of Grain, we are building a Shell gasification plant, which was inaugurated when Mr. W. K. Hutchison, C.B.E., who is here today, was Chairman of the South Eastern Gas Board. We are all very pleased indeed to welcome Mr. Tuyn, of B.I.P.M., Holland, the originators of the Shell gasification process. (*Applause.*)

I mentioned, earlier in my remarks, that education is a subject that will be reviewed at this Autumn Research Meeting. We are fortunate in having at this luncheon a number of representatives who are concerned with education. I would mention in particular Sir Charles Morris, the Vice-Chancellor of the University of Leeds; Professor Garner, of the University of Birmingham; Professor Saunders, of the Imperial College of Science and Technology; Professor Donald, of the University of London; Professor Roberts, of the University of Leeds; Mr. J. A. Hudson, of the Ministry of Education; Dr. J. E. Richardson, President of the Association of Principals of Technical Institutions, and Mr. A. D. Graham, Head of the Department of Technology of the City and Guilds of London Institute. We have also Mr. Dinsmore, the Principal of Brooklands Technical College. The help that we have received from these gentlemen in the operation of our education schemes is very greatly appreciated. We are giving much attention to education because unless we have

young men coming along we shall not make progress in our gas industry, and I should like especially to thank all these gentlemen for coming here to join us today. (*Applause.*)

No gathering of distinguished people such as this would be complete without the representation of kindred associations and organizations. I would mention first Professor Saunders. I have already referred to him under education, but now he wears another hat and appears as the President of The Institution of Mechanical Engineers. (*Applause.*) We have also and welcome, Mr. Hutchison, the President of The Institution of Chemical Engineers. He, also, is wearing another hat. (*Applause.*) We have, too, Dr. Macfarlane, President of The Institute of Fuel; Dr. McLellan, President of The Institution of Water Engineers; Mr. L. C. C. Rayner, President of The Institution of Heating and Ventilating Engineers; Mr. Dyson and Mr. Burt, the Deputy Chairman and the Director respectively of the Society of British Gas Industries; Dr. W. Idris Jones (President) and Dr. D. T. A. Townend, C.B.E., (Director General) British Coal Utilisation Research Association; and also Mr. G. W. Lee, Director of the British Coke Research Association, and Dr. N. Astbury, Director of the British Ceramic Research Association. We have also Dr. Baird, of the British Coking Industry Association; Dr. Pratt, Director of the Chemical Research Laboratory, and Dr. Bennett, the Chairman of the Parliamentary and Scientific Committee—an excellent representation—and we are delighted to have them all with us. (*Applause.*) We now come to our own industry, and I want to say particularly how delighted we are to have with us today Sir Henry Jones, M.B.E., the Chairman, and Mr. Kenneth Hutchison, C.B.E., the Deputy Chairman, of The Gas Council. (*Applause.*) We value very much indeed the support we receive from them in all the activities of The Institution of Gas Engineers.

We extend also a very special welcome to the representatives of the Ministry of Power. We have here today Sir Dennis Proctor, the Permanent Secretary; Mr. Martin Flett, Dr. Cawley, Mr. Norris and Mr. Dixon. I am sure that I am expressing the views of all those present when I say how much we appreciate the collaboration we receive from all these gentlemen in the Ministry of Power. (*Applause.*)

I now refer to the press, and I take the liberty of coupling the technical press and the lay press together. Both of them serve us well, and if they, in their reports, are not always completely in agreement, our regard for them both is unchanged.

I come now to our principal guest, Sir Alexander Fleck, whom we are all delighted to have with us today. (*Applause.*) When I had the pleasure of inviting Sir Alexander to be our principal guest on the occasion of this Autumn Research Luncheon, I was anxious, as you will understand, to ensure that he would say "Yes" rather than "No", and so I suggested to him that, having retired recently from the chairmanship of Imperial Chemical Industries, Limited, he would obviously be having an easy time and that to come along to our Research Luncheon today would not involve any hardship. To my surprise, he replied that he was having a busier time now than when he was Chairman of I.C.I. From further discussion, it appeared that the reason was that so many people, like myself, were asking him to be the principal guest at their meetings. However, he agreed, and I am delighted, as we all are, that he is able to be with us today.

A most important work upon which Sir Alexander is engaged is in connexion with his chairmanship of the Advisory Council on Research and Development. It is a matter of very much satisfaction to us that the Minister of Power has chosen Sir Alexander and his Council to advise in connexion with our national fuel problems.

Sir Alexander has always shown very much interest in our gas industry, and it will be remembered with much satisfaction that he delivered the Murdoch Memorial Lecture to us in 1954. I remember being present on that occasion, when he gave us a talk on "Origins and Development of Gas for Industrial Purposes". It was a most notable occasion.

If I were to make but the briefest reference to Sir Alexander's achievements, I should be talking for a long time. I do not want to do that, because time is not too plentiful. I think, however, that I ought to tell you something that I heard recently about Sir Alexander and his activities in connexion with labour relations. I was told that, not long before his retirement, he attended a function when awards were being presented to workers in Imperial Chemical Industries who had been in the service of the company for a long period of years. The particular occasion to which I refer is when he was presenting watches—I think they were gold watches—to those who had achieved 50 years' service. I am told that Sir Alexander, presenting a watch to one man, remarked how delighted he was that the man had been with them so long, and wished him well in the future; to which the man replied: "The watch is all right, but had I known this was only a temporary job I should never have started." (*Laughter.*)

We prize very much the honour of having Sir Alexander here, and we await with very much interest his response to this toast. Members of The Institution of Gas Engineers, I ask you to rise and drink with me the toast of "Our Guests", coupled with the name of Sir Alexander Fleck. (*Applause.*)

Sir Alexander Fleck, K.B.E., D.Sc., F.R.S. (Chairman, Ministry of Power Advisory Council on Research and Development), in response, said :—

It is a great pleasure for me to reply on behalf of your guests. As is evident from the Chairman's remarks, we are a very heterogeneous company, and it is not possible for me to reply on behalf of individuals. That would be quite impossible. I shall confine myself to saying that it is a great pleasure to speak on behalf of your guests from overseas and your administrative guests—that is, Sir Dennis Proctor and the other gentleman who has a name very nearly approaching my own*—and then, of course, the guests from academic circles.

I see, away on my left, Sir Charles Ellis, and on my right Sir Robert Robinson. Both have come down from the Olympic heights of pure science to be associated, on the one hand, with the gas industry, and, in the case of Sir Robert Robinson, to be associated with some of those low fellows in the oil industry. (*Laughter.*) Still, it is a privilege to have Sir Charles Morris, who, after all, retains the pure aroma of education and literature, from Leeds.

It is a great pleasure to be introduced to this gathering by Mr. Cheetham. It is now something like 20 years since he and I became associated in various activities concerning gas. Since then, of course, I have learnt to appreciate his value as a commercial man and his work among gas plants, and to realize the high value of his work and advice. It is a very great pleasure to be associated with him this afternoon and to be able, on behalf of all the guests, to wish the Institution well for its 26th Autumn Research Meeting.

In the literature that has come to me, I am particularly interested to see that the Institution's education activities come under the umbrella of the Research Meeting. I always think that the The Institution of Gas Engineers did a very good piece of work when, along with the help of my late friend Sir George Beilby, it did so much to get the British public to understand the meaning of the word "therm". That was a very good piece of work by the Institution to make

* Martin Flett, Esq., C.B., Deputy Secretary, Ministry of Power.

the British public realize in some very definite measure the unit of heat and the unit that they were actually consuming.

Then, again on the educational side, gas engineers did a great thing when gas was a very young commodity. I have recently learned, that when the early sponsors of gas were showing the House of Commons of those days what a wonderful thing gas was, they had some kind of apparatus in which gas was passed along a pipe and lit at the end of it. All the Members of Parliament put on gloves because they were frightened to touch the pipe in case it was full of hot gas. That was a good piece of educational work to try to introduce a little idea of oxidation into the minds of Members of Parliament of those days.

The other thing that I am pleased to see is that The Institution of Gas Engineers supports its President with a Technical Committee to endeavour, I assume, to keep him straight and on good technical lines during the course of his presidency. Speaking as an old chairman, I am all in favour of presidents and chairmen having technical committees to keep them on sound lines.

There is one other thing that I learned with great interest. It is taken from the year 1829, not very long after gas was introduced. The *Westminster Gazette* of those days wrote that Murdoch, whom we all regard as the founder of the gas industry, had suppressed more vice than the Suppression Society had done and had been a greater police officer into the bargain. Men were afraid to be wicked when light shone on them. So the gas business did a great job of work in those days in the suppression of vice.

I must compliment the Institution on having a Research Meeting at this particular time. The climate for research in the gas industry is very good indeed. I would quote the Annual Report of the Advisory Council on Scientific Policy when talking about coal utilization. It says: "Recent developments employing high pressures and high temperatures have made progress". Of course, a tremendous lot requires to be done.

Again, we have the work and views put out by the Wilson Committee, all of which, I hope it will be agreed, will show that the climate to go on and do progressive research work is very good at this time. I am sure that your guests join with me in hoping that the gas industry will take advantage of this good climate and go on and push forward research work in general.

The fact that there is a good climate is my main message to you this afternoon. It is with great pleasure that we who are not in the gas industry note the spirit of research that obviously prevails through this Meeting. One might be frightened that with an industry where nationalization is so prominent—I shall not use the word "dominant"—there might be a tendency for the spirit of research to be lost and to recede, but the evidence of this Meeting and of this luncheon shows that this is not so.

Along with all your other guests, I wish The Institution of Gas Engineers—and you, Mr. Chairman—the very best of good luck in pursuing this spirit of research, which all the public evidence that we have shows is so necessary for the advancement of this industry, which plays such a big part in the whole of our national economy.

It is with great pleasure that I thank the Institution for the very good hospitality that it has given to its guests, including myself, and wish the 26th Autumn Research Meeting all the very best of success in its further discussions. Thank you very much. (*Applause.*)

Mr. G. le B. Diamond, C.B.E. (Chairman of the West Midlands Gas Board), in proposing the toast "The President", said:—

I have the honour to propose a very warmhearted and sincere toast. It is that of "The President".

It must now be 40 years since I first met the President, when we were both very young engineers trying to coax a recalcitrant water gas plant through its teething troubles. I might add that it is not the only recalcitrant thing we have coaxed during all these long years!

I have seen the President grow from strength to strength and I am delighted that he has now become our President, because he is not only a very able engineer, but he has very genial personal qualities. Among them—you may not all know this—he possesses a very dry sense of humour and is an excellent companion.

It is now my duty—and I do it most warmly and sincerely—to propose the health of the President of this Institution. (*Applause.*)

The **President,** in response, said:—

Thank you very much indeed, Mr. Diamond, for your very kind words. I remember those days when we endeavoured to make some of those recalcitrant water gas plants perform. And thank you, Gentlemen, very much for the way in which you have received Mr. Diamond's remarks. Thank you. (*Applause.*)

Royal Charter and By-Laws

A booklet embodying the Royal Charter, Supplemental Charters and amended By-Laws of The Institution of Gas Engineers is being printed and a copy will be sent, as soon as possible, to every member of the Institution. The amended By-Laws, which give effect to the Resolution passed by Corporate Members at the 96th Annual General Meeting and have been approved by the Privy Council, come into operation on 1st January, 1961.

Members are particularly requested to note that the initials which they are entitled to use after their names have been amended. The correct initials for the different classes of membership are henceforth:—

Honorary Life Member ..	Hon.Life M.I.Gas E.
Honorary Member	Hon.M.I.Gas E.
Member	M.I.Gas E.
Associate Member	A.M.I.Gas E.
Companion	C.I.Gas E.
Associate	Assoc.I.Gas E.
Graduate	Grad.I.Gas E.
Student	Stud.I.Gas E.

Library Facilities

Members of the Institution are reminded of the facilities that exist for the consultation and/or borrowing of books and papers, and the perusal of technical journals, *etc.*, in the library and reading room of the Institution at 17, Grosvenor Crescent, London, S.W.1.

Books

The library contains a wide collection of textbooks, reference books, pamphlets, reports, *etc.*, relating primarily to gas engineering and its allied sciences. Most of these books may be borrowed, either by personal visit or by post.

New books are purchased on the recommendation of the Library Committee, which invites suggestions from members of the Institution. Gifts of books are also received from time to time, and a limited number of books are purchased each year from the Glasgow Bequest. In selecting the latter, preference is given to standard works published in the United States of America and of particular value to students.

Papers Presented at Meetings

An arrangement has been made with the District Sections and Associations and with the Junior Gas Associations whereby copies of all papers presented to these bodies are lodged in the library of the Institution, where they are available for consultation or loan. Abstracts of these papers are published in the Institution's *Journal* for the guidance of members.

Translations

The Institution is not in a position itself to make translations of foreign publications, but it is making a collection of English translations of selected foreign papers and articles, which are kept in the library and are available on loan. The co-operation is particularly sought of all who have to arrange to make such translations, by sending particulars of them to the Secretary of the Institution and, if possible, presenting a copy of their English translation to the library. A first list of translations was published in the Institution *Bulletin* for September, 1959 (pp. 4 and 5), and further lists will be published in the *Journal* from time to time.

Technical Journals

Current issues of more than 150 technical periodicals relating directly or indirectly to the gas industry are displayed for consultation in the reading room of the Institution, and bound runs of many of these are kept on the shelves. In addition to British journals, those displayed include the principal gas periodicals from Australia, Austria, Belgium, Canada, Denmark, France, Germany, Holland, Italy, Japan, Sweden, Switzerland and the United States of America.

New Accessions

A short list of the more important new accessions to the library will be included in each issue of the *Journal*. The complete list of books and periodicals received during the year is published in the Annual Report of the Council. Members are invited to send to the Secretary, for consideration by the Library Committee, suggestions for the purchase of new books or periodicals relating to gas engineering or to allied sciences or technologies.

Inter-library Loans

The librarian of the Institution can often obtain for loan to members books that are not available in the Institution's library. This is possible through the inter-library lending systems of the National Central Library, the Science Museum Library, and the Association of Special Libraries and Information Bureaux, with all of which the Institution co-operates.

Reproduction from Scientific Periodicals

The Institution of Gas Engineers is a signatory to the Fair Copying Declaration of The Royal Society, which facilitates the consultation by members of particular papers appearing in scientific periodicals not readily available to them. The Institution is enabled to supply to a member a single reproduction of an article, if this is required for the sole purpose of private study or research and provided that he undertakes not to sell or reproduce for publication the copy supplied. Under the conditions of the Declaration, the Institution is prepared to supply to a member, at cost, a single photocopy of an article or part of an article required for his personal use.

Ernest Woodhouse Smith

Sir Ernest Woodhouse Smith, C.B.E., F.R.I.C., Hon.M.I.Gas E., M.I.Chem.E., F.Inst.F., whose death on 7th November, 1960, at the age of 76, is recorded with deep regret, was educated at the Victoria University, Manchester. In 1907, he became the first Research Chemist to be appointed by The Institution of Gas Engineers to work at the University of Leeds. He joined the Birmingham Gas Department in 1910, and was Chief Chemist of the Department from 1912 to 1920, when he was appointed Technical Director of the Woodall-Duckham Companies, a post he held till 1944. He was awarded the Institution Silver Medal in 1911 and the Birmingham Medal in 1943. He was elected a Member of the Institution in 1913 and an Honorary Member in 1957.

Sir Ernest had a long and close connexion with The Institution of Gas Engineers and with the fuel industries generally. He served on the Council of the Institution and on the Council of the Society of British Gas Industries, of which he was Chairman in 1931-32 and President in 1954. He was President of The Institute of Fuel in 1943-45, President of the National Smoke Abatement Society in 1954-56, and Chairman of the Industrial Coal Consumers' Council in 1947-57. He was also Honorary Secretary of the World Power Conference, London, in 1928, and Technical Adviser to the Area Gas Supply Committee of the Board of Trade in 1929, his service in the latter capacity leading to his being created a C.B.E.

Sir Ernest took an active part in the formation of the Gas Research Board and served on its Council and Committees. In 1941, he was appointed Director-General of Gas Supply at the Board of Trade, where his work was of outstanding value in assisting the gas industry to surmount its wartime difficulties.

The above were only some of Sir Ernest's activities during his very full life, in which he worked tirelessly to further the interests of the Institution, the gas industry and the fuel industries in general.

Proceedings of Council

The following matters of general interest were among those dealt with by the Council:—

COUNCIL MEETING, 1st NOVEMBER, 1960

Reports were received of meetings of the following Committees of the Institution:—

(1) GAS DISTRIBUTION COMMITTEE, on 6th October

The Committee had considered, *inter alia*, a report of tests for leakage from gasholders, information regarding the use of copper service pipes, and the external protection of steel pipes.

(2) GAS WORKS SAFETY RULES COMMITTEE, on 13th October

Further consideration had been given to the amendments of certain of the I.G.E. Safety Recommendations.

(3) CODES OF PRACTICE SUB-COMMITTEE, on 18th October

(*a*) It was noted that the membership of the Committee is now representative of every Area Board.
(*b*) The Committee had considered suggestions in connexion with the revision of the Code on Domestic Space Heating by Independent Gas Appliances.
(*c*) The Committee had reviewed the work of all its Drafting Panels.

(4) GAS EDUCATION COMMITTEE, on 5th October

Recommendations in regard to the award of James Archibald Maclay Memorial Prizes were approved.

(5) SALES TRAINING COMMITTEE, on 17th October

The Council approved a formal application from the Scottish Association of Gas Managers to become the Scottish Section of The Institution of Gas Engineers as from the conclusion of the next Annual General Meeting of the Association, in September, 1961.

A report was made of a meeting of the Council of the International Gas Union in Copenhagen on 13th and 14th October with particular reference to the admission of the Polish Gas Association to membership of the Union, progress reports of the various Committees, and the proposed reorganization of the Committee structure of the Union after the Stockholm Conference.

Reports were received from Mr. A. Simmons about the Conference of The Institution of Fire Engineers on 26th to 28th September, and from Mr. A. V. Horsfall about the 1960 National Safety Congress of the Royal Society for the Prevention of Accidents, at which they had respectively represented The Institution of Gas Engineers.

A report was also made of the joint Symposium on Corrosion, held in Birmingham on 22nd and 23rd September, at which the attendance had exceeded 200.

It was reported that Mr. W. R. Branson had been appointed to represent The Institution of Gas Engineers on the Engineering Advisory Committee of the College of Advanced Technology, Birmingham, upon which Mr. F. L. Atkin represents The Institution of Mechanical Engineers.

COUNCIL MEETING, 15th NOVEMBER, 1960

A short meeting of the Council was held at The Church House, London, S.W.1, immediately preceding the opening session of the 26th Autumn Research Meeting, to consider matters relating to the programme of the Meeting.

COUNCIL MEETING, 6th DECEMBER, 1960

The Council appointed a panel of five of its members to adjudicate and recommend on papers for the award of the Institution's Gold Medal and H. E. Jones London Medal for 1960.

Reports were received of meetings of the following Committees of the Institution:—

(1) GAS WORKS SAFETY RULES COMMITTEE, on 29th November

(*a*) The Council received with regret the resignation of Mr. T. C. Battersby, M.B.E., as Chairman of the Committee, owing to increasing pressure of his other duties.
(*b*) Representatives of the Committee had discussed with representatives of the Institute of Petroleum comments received from the latter in regard to the Institution's Memorandum on Installations for the Use of Light Petroleum Distillates.
(*c*) Consideration had continued of the amendment of certain of the I.G.E. Safety Recommendations.

A report was made of a further meeting of representatives of the Institutions of Gas, of Electrical and of Water Engineers concerning recommendations in regard to the electrical bonding of services.

A report was made of an informal meeting of senior officers of The Coke Oven Managers' Association and of the Institution in the morning, and of the Joint Technical Meeting of the Institution, the Association and the British Coke Research Association in the afternoon, of 2nd November.

Retirement of Secretary

Members will learn with regret that, at the conclusion of the 98th Annual General Meeting, Dr. W. T. K. Braunholtz, O.B.E., M.A., will retire from the Secretaryship of The Institution of Gas Engineers. Dr. Braunholtz joined the Institution as Technical Assistant Secretary on 1st January, 1935, and succeeded Mr. J. R. W. Alexander as Secretary on 30th June, 1937.

The Council has appointed Mr. A. G. Higgins, M.Sc. (Assistant Secretary) to the post of Secretary as from 20th May, 1961. Meantime, he will be known as Secretary-Designate. Mr. Higgins joined the Institution as Assistant Secretary on 1st December, 1943.

To fill the vacant post of Assistant Secretary, the Council has appointed Mr. J. R. Davidson, B.Sc., with effect from 1st January, 1961. Mr. Davidson, who is 32 years of age, graduated with First-class Honours in Science at the University of Glasgow, following this with three years' post-graduate research in physical organic chemistry. He was for 3½ years research chemist at Mullard Research Laboratories, and is at present an Administrative Assistant with The Royal Society, London.

Education Regulations

Associate Membership Regulations

The 36th and 37th Reports of the Gas Education Committee (*Communications* 553 and 576 respectively) contain details concerning the revision of the regulations for the Associate Membership Exmination, which are to become operative as from the examinations to be held in October, 1962.

The revised regulations are now being printed and will be available, early in 1961, from the Secretary of the Institution.

Examinations of the City and Guilds of London Institute

The final examinations in Gas Technology (Manufacture) and Gas Technology (Supply) under the existing regulations are to be held on 5th and 6th June, 1961. (See *Bulletin* No. 72, November, 1960, p.6.) They are to be replaced by examinations in Gas Technology (Manufacture), Gas Technology (Distribution), and Gas Technology (Utilization). Regulations for the examinations in Manufacture and Distribution are still under consideration, but those relating to Gas Technology (Utilization) have been published and are available from the City and Guilds of London Institute, 76, Portland Place, London, W.1, price 1s. per copy, post free.

Although it was originally intended to hold the first examinations in Gas Technology (Utilization) in 1962, it has been agreed, in response to a number of requests from Area Gas Boards and Technical Colleges, to conduct the first examinations for the Intermediate Grade in 1961, as follows:—

First written paper:	Tuesday, 9th May, 1961 6.30 to 9.30 p.m.
Second written paper:	Wednesday, 10th May, 1961 6.30 to 9.30 p.m.

Certificate in Gas Salesmanship and Consumer Service

In consequence of the revision of the examinations in Gas Technology of the City and Guilds of London Institute, it has been necessary to amend the regulations for the Institution's Certificate in Gas Salesmanship and Consumer Service. The revised regulations for this examination are being printed and will be available, early in 1961, from the Secretary of the Institution.

Joint Technical Meeting

A Joint Technical Meeting of members of The Institution of Gas Engineers, The Coke Oven Managers' Association and the British Coke Research Association was held at The Church House, London, S.W.1, on the afternoon of Wednesday, 2nd November, 1960. The Chair was taken by Mr. H. J. Victory (President, Coke Oven Managers' Association), who was supported by the President of The Institution of Gas Engineers (Mr. H. S. Cheetham) and the Chairman of Council of the British Coke Research Association (Sir Frederick Scopes).

A paper, entitled "The Coke Oven: Retrospect and Prospect", by D. T. Barritt, B.Sc., M.I.Chem.E., F.Inst.F., and V. Robinson, M.A., M.I.Chem.E., was presented and discussed.

In the evening, the President and Council of the Institution received, informally, at the headquarters of the Institution, the President and Council of The Coke Oven Managers' Association and the Chairman and Council of the British Coke Research Association.

Australian Gas Industry Convention

An Australian Gas Industry Convention, sponsored by the National Gas Association of Australia, the Australian Gas Institute and the New South Wales Institute of Gas Engineers, was held in Sydney, New South Wales, on 17th to 20th October, 1960.

The President of The Institution of Gas Engineers was unfortunately unable, owing to his many other commitments, to attend the Convention, but he prepared a tape recording of a message of greeting, which was taken to Sydney by Mr. John F. West, M.A., M.I.Gas E., who represented the Institution on behalf of the President.

Mr. N. G. Mather, M.I.Gas E., who was President of the Australian Gas Institute at the time of the Convention, has since written to Mr. H. S. Cheetham as follows:—

> "This letter is to thank you once again for the tape-recorded message of greeting from Britain, which you sent to the Convention by the hand of Mr. John West.
>
> It was delivered to the assembly on the morning of the official opening by the Minister, and a reproduction of your photo was thrown on the screen at the same time.
>
> Everyone present was delighted to hear you, and your handling of the text has done much to cement the strong ties between this country and Britain.
>
> It is Mr. West's intention to see you when he returns to England and give you a few impressions of his visit.
>
> You could not have chosen a better ambassador."

In addition to Mr. Mather's Presidential Address to the Australian Gas Institute, the following papers, copies of which are in the library of the Institution, were presented at the convention:—

- "The Place of Oil and Gas in the Australian Energy Field", by J. W. Bell.
- "Production Scheduling in a Complex Gas-making Process", by Miss V. G. Steward.
- "Gas Purification", by P. L. Spedding, M.Sc.
- "The Use of Low-density, Low-iron-content Mixtures for Gas Purification", by D. E. Radford, A.R.A.C.I.
- "Overseas Trends in Hydrogen Sulphide Removal", by W. S. McGowan, B.Sc.
- "Economic Aspects of Removing Organic Sulphur", by B. B. Bennett and J. G. Baker.
- "Network Analysis of Gas Distribution Systems by Electronic Digital Computer", by J. C. Challis and M. J. Williams.
- "Planning for Increased Appliance Sales", by R. G. Trevillian.

District Sections and Affiliated Associations

(a) Notes of Meetings

Eastern Section

A meeting of the Section was held on 30th November, 1960, at the headquarters of The Institution of Gas Engineers, when the Chairman (Mr. E. H. Winch, Cambridge) welcomed Mr. H. S. Cheetham (President, The Institution of Gas Engineers).

The Chairman, in handing to Mr. R. J. Gavin (Immediate Past-Chairman) a transistor wireless set as a memento of his year of office, gave a brief outline of his career in the gas industry and local affairs.

Mr. H. S. Cheetham presented Associate Membership Certificates to successful candidates, and, in thanking the Chairman, Mr. Winch, for his welcome, the President recalled that it was some 30 years ago when he became a member of the Eastern Counties Gas Managers' Association. He had always enjoyed his attendance at their meetings.

The President then spoke briefly of the importance of the plants now being built for the gasification of coal and oil under pressure. He said that we were all anxious to have the operating results from these new plants, but he suggested that, in the meantime, there were possibilities of economies in gas manufacture in existing plants. He spoke of our latest gas appliances, which compared, he contended, most favourably with those available in any other country.

Mr. D. W. Ault, B.Sc.(Eng.), M.I.Gas E., A.M.I.Mech.E., Production Engineer (Eastern), and Mr. P. L. Henderson, A.M.I.Gas E., Senior Works Study Officer, both of the East Midlands Gas Board, presented their paper entitled "Work Study as Applied to Oxide-handling Plant in Tower Purifiers". There was a long discussion, after which Mr. Bernard Clarke, M.B.E. (Divisional General Manager, Lincolnshire Division, East Midlands Gas Board), proposed a vote of thanks to the authors.

Before the close of the meeting, Mr. S. L. Wright (Cardiff) thanked the Chairman for his welcome and expressed greetings from the Wales and Monmouthshire Section, which were cordially received.

London and Southern Section

(*a*) The first meeting of the session, the Tenth Annual General Meeting, was held at a new venue, the Caxton Hall, Westminster, on 18th October, 1960. Mr. J. A. Hepworth, the new Chairman, was introduced and then presented to the outgoing Chairman (Mr. R. F. Robinson) a memento of his year of office. On this occasion, it took the form of photographic apparatus. In making the presentation, Mr. Hepworth congratulated Mr. Robinson on a very successful year of office and complimented him on the excellent papers presented, terminating in his Chairman's Address on the occasion of the Spring Meeting. He referred also to the enjoyable visit to Dunstable in June. In thanking the members for the memento, Mr. Robinson said he had enjoyed his year of office and had made a large number of friends both inside and outside the industry. The attendance at the meetings had been good and he thanked the officers of the Section for their help and co-operation.

The minutes of the Ninth Annual General Meeting were then read and approved, and the Report of the Committee of Management for the session 1959-60 was accepted without comment. Mr. A. F. Grant was elected Junior Vice-Chairman.

On behalf of the Institution, the Chairman presented Associate Membership Examination Certificates to successful candidates who attended the meeting, and wished them well in their future careers.

A paper on "Forecasts—Domestic Gas and Appliance Sales" was then presented by Mr. J. A. Buckley (Sales Manager, North Thames Gas Board). Several members took part in the discussion of the paper, to which the author replied individually.

In proposing the vote of thanks to the author, Mr. R. M. Farror (Senior Vice-Chairman) drew attention to the increasing prevalence of bulk delivery of oil for heating, and considered that the advantages of gas should be more fully published. In the South Eastern Gas Board Area sales of space heating appliances were expected to give a 3 per cent increase in the peak-load demand, and it would be very useful to know details of the type of appliances that are being sold, in order to gauge the effect on variation of supplies. He mentioned, however, that methods of gas production were now more flexible and as such should be able to meet the possible variation in demand.

(*b*) At the general meeting held on 22nd November, 1960, Mr. G. J. Bolton who had not been present at the previous meeting, was presented with his Associate Membership Examination Certificate and congratulated by the Chairman.

Mr. Storey then gave a paper on "Oil Refinery Operations and Refinery Gas Production".

In introducing Mr. G. R. Storey to the members, the Chairman referred to the happy relationship his Board had with Shell Refining Co., and gave a particular welcome to Dr. Belchetz. He considered that the gas industry would be more closely associated with the oil industry in the future and it would be an advantage to gas engineers to know more about refining plant and operational problems.

After a good discussion, the vote of thanks was proposed by Mr. R. M. Farror, who said the paper had been both interesting and informative. In visiting refineries, he had found it difficult to follow the various processes, but the paper described these very clearly. Like the oil industry, the gas industry needed to be flexible and choose processes capable of dealing with the largest possible range of feedstock. Petroleum products used by the gas industry at present amounted to less than 5 per cent of the total of raw materials, but the quantity was increasing and there was no doubt that the gas industry would need to learn more about refinery products.

Manchester and District Section

(*a*) The Section held a meeting at the Queen's Hotel, Manchester, on 28th October, 1960. It was preceded by luncheon at which the principal guest, Mr. L. W. Andrew, B.A., B.Sc. (Director of the Watson House Centre) was the speaker. There were some 80 members and guests present. Certificates for success in the Associate Membership Examination of The Institution of Gas Engi-

neers were presented to three successful students by Mr. W. Hodkinson, O.B.E. (Chairman of the Section).

Mr. Andrew then gave an account of the work and purpose of the Watson House Centre, illustrated by lantern slides, after which a great many questions were put to him concerning aspects of the work of the Centre. The discussion had to be brought to a conclusion by the Chairman, who thanked Mr. Andrew for what had obviously been a stimulating talk. In his reply, Mr. Andrew said how glad he was to have the opportunity to come to this meeting of the Section, and commented that, although it was doubtless good for the members to have the opportunity of questioning him closely on the work of the Centre, it was equally valuable to him to be able to sense the feelings of the members in Lancashire, Yorkshire and Cheshire.

(*b*) The Section met in Manchester on 2nd December, 1960, the Chairman (Mr. W. Hodkinson, O.B.E.) and 75 members and guests had luncheon prior to the meeting at which Mr. S. G. Deavin, O.B.E. (Member and Secretary, North Western Gas Board), gave a paper entitled "Pricing in the Gas Industry".

The paper was followed by an animated discussion in which many members took part with ideas for charging for large supplies of gas, methods of charge for modern usage associated with all-gas heating, the use of better alloys for the construction of appliances in lieu of sulphur-free gas, the principles of tariffs for commercial customers, and in regard to the idea that the prepayment meter has perhaps served its day. To all of these Mr. Deavin gave a full reply, and thanked the members for the stimulating discussion.

Midland Section

The Autumn Meeting of the Midland Section was held on 27th October, 1960, at the Essex Works, Birmingham, of John Wright and Company, Limited.

In the morning, Mr. W. J. Parsons (Divisional Sales and Service Officer, Birmingham Division, West Midlands Gas Board) presented a paper under the title "Opportunity Knocks". Mr. S. K. Hawthorn (Chairman of the Section) proposed a vote of thanks to Mr. Parsons, which was carried with acclamation. Members were then entertained to luncheon by the Company. Mr. Christie (General Manager) welcomed the visit of the Section and said they were very grateful to have been able to sit in at the reading and discussion of the paper. Mr. S. K. Hawthorn, replying, said that the future of the gas industry depended upon the expansion of sales and the provision of more efficient appliances. Members were reminded that John Wright and Company were pioneers in the design of gas appliances and had been one of the largest manufacturers of such appliances during their 90 years of existence. He thanked them for their hospitality and said that he and members of the Section were looking forward to their tour of inspection of the works during the afternoon.

Mr. Hawthorn was supported by Mr. G. le B. Diamond, C.B.E. (Chairman, West Midlands Gas Board), Mr. A. Gwynne Davies, M.B.E. (Secretary, East Midlands Gas Board), and by a number of the principal officials of the two Boards.

South Western Section

The Annual General Meeting of the South Western Section was held at Bristol on Wednesday, 19th October, 1960, with some 50 members and guests present. The proceedings were presided over by Mr. A. C. Rea (Chairman), and, prior to the meeting, luncheon was taken at the Grand Hotel, Bristol.

Mr. Rea welcomed Mr. H. S. Cheetham and Dr. W. T. K. Braunholtz, O.B.E. (President and Secretary of the Institution respectively) together with Mr. James Carr, O.B.E. (Deputy Chairman, South Western Gas Board), and Mr. L. P. Ingram, M.B.E. (Chief Engineer).

Mr. T. W. Jackson was elected Chairman, Mr. R. J. Williams Senior Vice-Chairman, Mr. T. W. Clapham Junior Vice-Chairman, and Mr. F. C. Gay, M.B.E., Honorary Secretary for the ensuing year.

It was unanimously agreed that the annual donation to the Institution Benevolent Fund should again be 30 guineas, and both Mr. Cheetham and Dr. Braunholtz referred to the generosity of the Section and to the special way of increasing their contribution by "passing the hat around" after the luncheons that preceded general meetings. On this occasion, the luncheon collection totalled £5 13s.

For the benefit of members, Mr. Cheetham outlined details of the Institution *Journal*, which would be published monthly as from 1st January, 1961.

The Annual Report and Accounts for 1959-60 were unanimously adopted.

The retiring Chairman (Mr. A. C. Rea) gave an Address on the production and economics of gas manufacture, together with details of developments carried out at the gas works under his control.

Mr. L. P. Ingram, M.B.E., congratulated Mr. Rea on his excellent address, and expressed appreciation of the valuable work undertaken by him.

Mr. Rea introduced the new Chairman of the Section (Mr. T. W. Jackson), who expressed appreciation of the honour conferred upon him and congratulated the retiring Chairman on having achieved a very high standard in his programme during the past session.

The incoming Chairman presented Mr. Rea with the Past Chairman's Badge to commemorate his year of office, together with a tape recorder as a personal memento.

Eastern Junior Gas Association

The annual short paper competition of the Association was held at the Gas Showrooms, George Street, Luton, on Wednesday, 7th December, 1960, by kind invitation of the Eastern Gas Board and Mr. T. C. Battersby, M.B.E. (Controller, Tottenham and Watford Divisions). The meeting was attended by 54 members and guests.

The President's Prize was awarded jointly to Mr. R. A. Janes and Mr. J. R. Lane; and Mr. J. F. Smith and Mr. R. E. Clarke were also presented with awards.

The President congratulated all the competitors in a competition that had been of a high standard and in which the marking had been so close as to present the adjudicators with much difficulty in deciding the order of placing.

London and Southern Junior Gas Association

(*a*) The annual reception and dance of the London and Southern Junior Gas Association was held on Friday, 4th November, 1960, at the Caxton Hall, Westminster. The President (Mr. P. J. Savage) and Mrs. Savage received 180 members and guests, who enjoyed an evening of sociability and dancing.

Dr. A. E. Haffner (Southern Gas Board), the principal

guest, spoke in warm terms of the work of the Association and its able President, whose career he had followed since his earlier days at Fulham. Mr. Savage replied, thanking Dr. Haffner and, also, Mr. Duggin for his work in organizing the Dance.

(*b*) The Association visited the Works of W. H. Allen, Sons and Company, Limited, at Bedford, on 24th November, 1960. About 50 members were shown every phase of the manufacture of the wide range of products of this Company, including all types of pumping machinery, steam engines, turbines, generators and alternators. The visit proved both enjoyable and instructive.

Members were the guests of the Company at luncheon and tea. The appreciation of the party was expressed by the President (Mr. P. J. Savage).

Manchester District Junior Gas Association

On 12th November, 1960, the President (Mr. J. A. Taylor) and about 70 members of the Association visited the works of Courtaulds, Limited, at Trafford Park, Manchester.

During the tour of the works, the members saw the manufacture of carbon disulphide, of which Courtaulds are one of the largest producers in the country, together with the ancillary producer gas plant. Visits were also made to the new carbon tetrachloride plant and the contact plant for the manufacture of sulphuric acid.

On the completion of the works' visit, the members heard a talk on the range of textile products produced from Courtaulds' yarns and inspected a display of them, following which they were entertained to a buffet luncheon.

Mr. C. A. Young expressed the thanks of the Association to Courtaulds for the arrangements made for the visit and the hospitality provided.

Northern Junior Gas Association

(*a*) The Association met at the Continental Hotel, Sunderland, on 20th October, 1960, and were welcomed by the President (Mr. G. E. Haddon, Stockton-on-Tees).

Owing to the indisposition of the Honorary Secretary (Mr. R. Proud), the Senior Vice-President (Mr. L. Nelson) acted as Secretary.

The President introduced Mr. W. H. Deans (Assistant Lecturer in Gas Fitting at the Stockton-Billingham Technical College), who read a paper entitled "Training Gas Fitting Apprentices".

In proposing a vote of thanks to Mr. Deans, Mr. S. G. Irvin (Newcastle), said how pleased he was to see so many guests, and recollected the time, many years ago, when a paper on "Gas Fitting" only was read at a Junior meeting. As a teacher of student gas engineers, he agreed with Mr. Deans' paper in general, and said that these student gas engineers were also taking the City and Guilds Final Gas Fitting Examination as part of their general training.

Mr. Deans thanked members for the way they had discussed his paper and for the many suggestions put forward.

Following the meeting, members were entertained to tea. A vote of thanks to Mr. W. O. Kirkwood (Divisional General Manager, Sunderland Division, Northern Gas Board) was proposed by Mr. C. H. Ling.

(*b*) The Association met at Newcastle-upon-Tyne on 24th November, 1960. The President (Mr. G. E. Haddon), having welcomed members, introduced Mr. E. Sheldon (Middlesbrough), who read his paper "Opportunity in Prosperity".

Mr. R. J. K. Shepherd (Carlisle) proposed a vote of thanks to Mr. R. Sheldon, and said that no one could question the author's sincerity and enthusiasm. Combined efforts from manufacturing, sales and distribution staffs were required to increase the sales of gas. An all-out drive should be made to increase therms per consumer, particularly on new housing estates where the Board had large capital outlays in providing mains.

Members were then entertained to tea by the courtesy of Mr. W. Sutcliffe (General Manager, Tyneside Division, Northern Gas Board), and a vote of thanks to Mr. Sutcliffe for hospitality was proposed by Mr. Cummings.

Western Junior Gas Association

(*a*) The Annual General Meeting of the Association was held at Taunton on Saturday, 15th October, 1960, 47 members being present.

Following the presentation of the Annual Report of the Council and the 1959-60 Accounts and Honorary Treasurer's Report, officers for the 1960-1961 session were elected:—President, Mr. F. Tweedle (Bath), Senior Vice-President, Mr. D. H. P. Hammond (Weston-super-Mare), Junior Vice-President, Mr. J. Parker (Bath), and Honorary Secretary, Mr. J. D. Pickard (Bath).

The retiring President (Mr. T. A. Nicholson, Taunton) then presented his Presidential Address, following which a vote of thanks was proposed by Mr. T. N. Dent (Area Development Manager, South Western Gas Board).

Mr. Dent handed to Mr. G. Howse and Mr. G. W. Jobbins the silver medals awarded by the Society of British Gas Industries for their paper, "Automatic Gas Controls", presented to the Association on 6th May, 1959. This paper was also awarded an Honorary Members' Prize by the Association.

Other Honorary Members' Prize winners were Mr. J. J. Long for his paper "Ducted Warm Air Heating", and Mr. P. Trevelyan for his paper "The Use of P.F.D. in Continuous Vertical Retorts".

The incoming President (Mr. F. Tweedle) was inducted into office by Mr. Nicholson, and this ceremony was followed by the presentation to Mr. Nicholson of his Presidential Certificate and an inscribed clock to mark his year of office.

(*b*) Forty members of the Association and guests assembled at Swindon on Saturday, 12th November, 1960, for the inaugural meeting of the 1960-61 session. During the early afternoon, the Swindon manufacturing station of the South Western Gas Board was open for inspection, by courtesy of the Works Engineer and Manager (Mr. P. G. Whitehead). Members were able to inspect extensions to the manufacturing plant completed within the last two years and bringing the total works capacity up to 11 mill. cu. ft/day.

Following the tour of the works, members adjourned to the Gas Showrooms to hear Mr. A. Riley (Swindon) present his paper "Gas on the Right Lines".

At the conclusion of the meeting, Mr. T. A. Nicholson (Taunton) proposed a vote of thanks to the South Western Gas Board for the facilities provided, and to Mr. A. Horsfield (District Manager) and Mr. P. G. Whitehead (Works Engineer and Manager) for the arrangements they and their staff had made.

(b) Abstracts and Discussions of Papers

Copies of the complete papers abstracted below are available for consultation or loan in the Library of the Institution.

London and Southern Section

"Forecasts—Domestic Gas and Appliance Sales", by J. A. Buckley (Sales Manager, North Thames Gas Board). Paper delivered in London on 18th October, 1960.

The paper refers to the short-term forecasts that had been in use for many years and based on information available from the Meteorological Office. It then outlines the method adopted by the North Thames Gas Board for arriving at forward estimates of appliance sales, and gives details of the factors and influences that must be taken into account. This includes an analysis of the estimated load obtained from the installation of domestic appliances over past years. Using information available from market research sources, Mr. Buckley gives a method of forecasting the trend in domestic gas consumption based on the anticipated sales of appliances. He then describes recent developments in the space heating and central heating fields, and the possible influence of these on domestic gas consumption.

Discussion

Mr. T. V. GARRUD (London) opened the discussion and said that there was no doubt that the future of the gas industry depended on successful sales. He hoped that the future might prove the author to be hopelessly wrong in some of his estimates, but he was very much in agreement with the views given in the paper.

Mr. J. D. C. WOODALL (Croydon) referred to the use of long-term weather forecasting and the meteorological forecasts given weekly by the B.B.C. He was doubtful whether the statistical method given by Mr. D. G. Rose some years ago was of any value, since this did not take into account the effect of increased sales of appliances. He considered that the true effect of these sales would not be known until some really cold weather was experienced.

Mr. S. EVERARD, M.B.E., (London) referred to the loss caused by the replacement of old-type cookers by new and very much more efficient cookers, but considered that if new cookers had not been very efficient, the load might otherwise have been entirely lost.

Mr. S. A. KING (London) criticized some of the methods of forecasting sales and said he could not agree with some of the trends expressed. He considered that the industry should concentrate on space heating appliances rather than on central heating appliances.

Mr. G. H. MADGE (London) complimented the author on his statistical approach to the subject and stressed that tariffs were absolutely necessary and vital and that every effort should be made to maintain the cooking load.

Mr. L. C. POULTER (London) considered that the price of gas was the absolute factor to control future sales.

Mr. D. G. ROSE drew attention to the 20 per cent drop in the sale of coal. He queried the share that the gas industry might take.

"Oil Refinery Operations and Refinery Gas Production", by G. R. Storey (Shell Refining Company, Limited). Paper delivered in London on 22nd November, 1960.

The paper discusses the structure of a modern oil refinery together with the general principles governing its operation. It then describes some of the more important processes, in particular those directly concerned with the production of gas. Finally, it gives an outline of the treatment applied to the gas sold to the gas industry.

Discussion

Dr. A. E. HAFFNER (Southampton) reminded members it was the gas industry that opened up the field of distillation, and referred to the difference in the terms and definitions of gas in tons and liquid in barrels used by the oil industry. The gas industry was faced with the same problem of balancing the products, but in addition had to consider seasonal effects. He felt that not much of the refinery gas produced reached the gas industry, and said that the nearer the composition of refinery gas approached that of coal gas the greater would be its use. Even so, 25 per cent of the output of the Southern Gas Board was derived from refinery gas.

Dr. Haffner raised a number of queries and considered the amount of gas burnt at flares to be excessive. He concluded by paying tribute to the considerable advantage to the gas industry of the technique developed by the oil industry in underground geological exploration.

The author replied to the queries raised by Dr. Haffner and said that output of refinery gas could possibly be increased, but that oil products were their main consideration and gas was only a by-product. The oil industry, also, had to be flexible in the production of its various products; for instance, at the moment in this country the oil industry was maximizing on fuel oil and minimizing on gasoline. He also emphasized that flares were provided for emergency relief of products.

Mr. L. J. CLARK, B.E.M. (London), said he was impressed with the number of similarities and also differences between the two industries. We lived today in a climate of continuous change and in consequence it was necessary to write off new plant in a fairly short time. He queried whether increased quantities of liquefied petroleum gases could be brought in with the crude oils, and in regard to refinery gas said the gas industry would welcome the removal of unsaturated compounds as these could not be easily reformed. In regard to the continuity of supply of refinery gas, he suggested that this might be guaranteed by making up any shortage of refinery gas by liquefied petroleum gases, not mixed with the refinery gas, but as a separate supply.

In reply, the author said that crude oils could take up to 5 per cent of gas, but, with the increased content, the loss in transit would increase. Liquefied petroleum gases could be supplied to make good deficiencies in refinery gas, but the market for liquefied petroleum gases was good and storage not cheap.

Mr. E. R. WARD (London) said the paper itself was an indication of the close relationship between the two industries, but felt that there was a difficulty in estimating for long-term programmes owing to the unpredictable changes that might occur within the oil industry.

The author agreed that the supply of gas was the least predictable.

Mr. E. R. STEWART (London) said the information given in the paper would have been extremely useful in the early days of reforming refinery gas at Romford. He mentioned that refinery gas was expressed in terms of therms by both industries. He referred to the inert-gas content of the refinery gas, which was given as 7 per cent, and said that at Romford this was only of the order of 1 per cent.

In his reply, the author said the quantity of inert gas could be variable and arose from the air used to burn off carbon from catalyst.

Midland Section

"Opportunity Knocks", by W. J. Parsons. Paper delivered at Birmingham on 27th October, 1960.

The paper attempts to survey the technical development in the space heating field and to assess how the gas industry stands in relation to its major competitors, electricity and oil. It examines the basic requirements for comfort in the home, and also the changed social conditions that have tended to alter the pattern of heat usage.

Electricity

The author outlines the technical requirements necessary to achieve a good standard of installation and performance and is of the opinion that this form of heating may be suitable for premises in continuous daily occupation. In the absence of reliable data, it is difficult to make comparisons of running costs.

Oil

The principal types of burner systems, using kerosene and domestic fuel oil, are reviewed, together with hourly heat inputs and maintenance rates. Installations up to approximately 50,000 B.t.u/hr employ vaporizing burners, kerosene being the fuel, whilst burners in excess of this rating are usually of the atomizing type using domestic fuel oil. The problems associated with vaporizing burners, particularly with regard to frequency of servicing, are discussed.

Vaporizing burner installations are of the semi-automatic type, i.e., high/low. Full automatic operation can be achieved with atomizing burners.

Small-bore Heating Systems

Design principles are discussed, based on the heat loss requirements of the structure. The availability of a small glandless pump has made the installation of accelerated hot water systems a practical proposition in domestic property, and the advantages of installing small-bore systems in occupied houses are given. Typical automatic control equipment is outlined, both for central heating and domestic hot water.

Warm Air Installations

This post-war development in the field of domestic heating is discussed, emphasis being placed on its extreme flexibility. The running costs and the standard of heating achieved using a Sugg Halcyon F45, together with a Radiation/"Parkray 30" solid-fuel convector, are given for a house of 1,500 sq. ft.

Overall Costs

The author quotes from "Central Heating in Your Home" (published by the Institution of Heating and Ventilating Engineers) the basic requirements necessary to make a sound choice of fuel and system, and compares gas in this respect with its principal competitors, oil and electricity.

Reference is made to competitive fuel costs, based on the cost per effective therm, quoted in articles on central heating in the national press in recent months. The author indicates that these do not give the complete position and quotes, from the above publication, tables prepared by the Institution of Heating and Ventilating Engineers giving total annual costs based on a 10-year depreciation for installations of 45,000 and 60,000 B.t.u/hr. A diagram is appended, illustrating the development of this argument, compiled from the average fuel prices throughout the country. From this, it is apparent that gas at 1*s.* 3*d.*/therm is competitive with kerosene at 1*s.* 6*d.*/gal. for the typical installation given with a standard pattern of usage of 2,000 hr per heating season, for installations up to approximately 60,000 B.t.u/hr, which will include the great majority of domestic dwellings.

Conclusions

Marketing remains the problem facing the gas industry if it is to achieve a major portion of the space heating load. Gas is now available at a competitive price, and a wide range of equipment is available to meet any heating requirement. The industry is ideally placed to provide an efficient after-sales service. Publicity needs to be more forceful in order that the public can be made fully aware of what the Industry has to offer.

Discussion

Mr. A. V. HORSFALL (Birmingham) opening the discussion, referred to off-peak electricity floor heating and quoted figures that indicated that the same degree of heating could be obtained by gas for about half the cost. He said The Gas Council was spending half its income on advertising, with particular emphasis on space heating.

Mr. S. JONES (Dudley) wondered if members really appreciated the urgency of this matter. Compared with the United States of America, domestic central heating was hardly used in this country. There should be a considerable increase in expenditure on advertising.

Mr. J. E. COOPER (Leicester) remarked that many of the ardent supporters of space heating were those who, in the past, had known nothing about the subject. Small-bore heating was first put forward by the oil industry. Mr. Cooper said he could foresee that many of the appliances now in use would soon become out-of-date.

Mr. J. CORRIGAN (Leicester) said it was never easier to sell gas. They were now in an era when gas was competitive with other fuels, but were they taking the opportunity?

Mr. WHITEHEAD (Stoke-on-Trent) doubted the disappearance of the open hearth as the focal point for heating, until a form of controlled radiant heating was achieved giving a uniform wall temperature of 70° to 80°F, with air temperature controlled at 50° to 55°F. Air temperature alone was no criterion of comfortable conditions. He detailed the advantages of the panel gas fire particularly in bedrooms, where it could be conveniently and cheaply fixed.

Mr. PARSONS, replying to the discussion, said it was obvious that marketing now caused no problem. Their competitors were really worried over the industry's new two-part tariffs, and these should be pushed for all they were worth. In his opinion, 95 per cent of the people did not know their two-part tariff. The important point was to believe in their own product and hit out in selling it.

Eastern Junior Gas Association

The following four abstracts are of papers delivered in a short paper meeting held at Luton on 7th December, 1960:—

"Mechanical and Operational Hazards of an O.N.I.A.-G.E.G.I. Catalytic Oil-gas Plant", by R. A. Janes (Dunstable).

The author acknowledges that much has already been written about oil-gas plants, and realizes that more information still remains to be obtained, particularly from a "time-and-experience" point of view.

The O.N.I.A.-G.E.G.I. units at Dunstable are regenerative and light distillate oil (P.F.D.) is processed by a two-way cycle (up-run and back-run). This method gives increased efficiency by balancing heat absorption, but the reversal of gas flow necessitates the use of extra valves, and steam purging becomes most important. A diagrammatic layout of one unit, listing control valves, is given. As these units are used to balance gas demands of the grid, mobility of production is essential, but operating problems are increased due to intermittent working.

Maintenance of the plant, particularly the hydraulic system, must be of a high standard with emphasis on speedy fault finding. It is shown that if a single fault occurs during any of the 147 individual valve movements in one cycle, the plant will close down. The cam contact method of passing hydraulic impulses is illustrated.

The paper concludes with the following observations:—

(1) Gas-making plants of this type are invaluable for meeting peak demands of a grid.

(2) Mobility is essential for this, but base-load working is essential for greater efficiency and low cost.
(3) If base loading is intended for two units, a third must be available.
(4) In view of innumerable moving parts, maintenance must be of the highest standard, with emphasis on preventive maintenance by thorough routine inspection.
(5) Due to the intricacies of maintaining such a plant, particularly the hydraulic systems, personnel designated for this maintenance should be given training by the plant contractor, or by the contractor's suppliers, prior to the plant being put to work.

"Liquor", by J. F. Smith (Watford).

The first section of this paper deals with the characteristics and quantities of some gas works liquors and briefly surveys any particular problems they may present in disposal or handling. Retort house liquors and complete-gasification plant liquors are compared on the basis of pounds of oxygen absorption per ton of coal carbonized as a convenient yardstick of the effluent-disposal problem they present. Attention is drawn to the difficulties created by the sulphur compounds in O.N.I.A.-G.E.G.I. plant liquor and the iron in purifier liquor. Carburetted water gas liquor is also briefly discussed.

The second section deals with methods of disposal. Concentration and discharge of effluent to sewer are noted and a short survey of biological oxidation, ion-exchange and complete chemical treatment is made, pointing out the limitations of these processes. Disposal to the land as a nitrogenous fertilizer is recommended as a convenient method requiring the minimum of plant and also as the one profitable method of disposal. The seasonal nature of this demand is noted.

Typical analyses of each type of liquor are given to illustrate the text.

"Human Relations and Communications", by J. R. Lane (Hitchin).

After referring to the interdependence of human relations and communications and their effect upon efficiency, this paper deals with a few general and practical matters of the main subject, particularly from the point of view of a "junior". Several causes for the stimulated interest in human relations in recent years are mentioned, and the responsibility for the continued improvement through the various forms of communication is asserted to be a primary concern of all management.

The continual practice by management of being available, and the several direct improvements in human relations that can result, are examined in some detail as an example of the practical application of a principle of good communications.

The conclusion draws attention to the position of the "junior" in the communication chain, and to the particular opportunities for the improvement of human relations in the gas industry.

"Some Aspects of Education by a Board's Pupil Engineer", by R. E. Clarke (Chelmsford).

As an introduction, the author mentions some examples of the typical duties a gas engineer will be expected to perform in 1970.

After discussing the exact function of a gas engineer on a manufacturing works, this paper considers the two main methods of training for this function and qualifying for Associate Membership of The Institution of Gas Engineers. The methods are: (*a*) part-time study and (*b*) sandwich courses.

The author gives his experience of part-time study, lists in tabular form the time spent in each department of the industry, and considers the advantages of this method of training.

Sandwich courses are then described in some detail, and a well-known person is quoted about his experiences on one of these courses and what he considers its advantages.

The author states that any training scheme must be a compromise between academic studies and practical experience and asserts that the part-time study method offers the best compromise. In conclusion, he lists what he considers to be the best form of the part-time study method of training.

London and Southern Junior Gas Association

"Paint Inspection in the Gas Industry", by A. H. Rayner. Delivered in London on 21st October, 1960.

This paper deals primarily with the inspection of painting on outside steel structures within the gas industry, and indicates how a comprehensive system of paint inspection should cover every aspect of painting from the design and construction of a plant to its ultimate replacement. This process is divided for discussion into four phases:—

(1) The design, specification, pre-treatment and initial painting before, during and after the erection of the plant.
(2) The inspection before repainting.
(3) The inspection during repainting.
(4) The inspection and regular examination after repainting.

Each of these phases is separately considered, and with each examples of the types of faults and pitfalls to be encountered given, together with the necessary qualifications for inspectors employed on the job. Stress is laid on the importance of eliminating potential sources of corrosion in the design stage of the plant, and of the correct specification of suitable pre-treatment and paint at that stage. The maintenance painting of water-sealed gasholders is particularly covered as being one of the prime sources of trouble in paint inspection. Particular mention is also made of the need for correct detailing of bills of quantity for contractors, and also on the attitude of the paint inspector towards contractors employed on the job. Finally, mention is also made of the need to keep adequate records of the painting history of each item of plant so that an increased knowledge of the behaviour of various types of paint under specific conditions should be obtained.

Discussion

Mr. W. J. GOODERHAM (London) spoke of the work of the stores testing laboratories of the North Thames Gas Board, of how it interlocked with Mr. Rayner's work and also with the work of the Research Department at Fulham. Of the inspection of paint itself, manufacturers were prone to work close to the lower limits set in specifications, and samples frequently failed on test, more so if not truly representative. With increased testing and inspection, manufacturers' methods had improved and the need for testing had decreased.

Mr. W. H. WHITE (London) spoke of the varying treatment required for materials, which might be steel, aluminium, wood, concrete, *etc.*, and the varying atmospheric conditions to which they were subjected. The more pernicious the conditions, the greater the care necessary in each aspect of their treatment. Referring to the discussion on L. A. Ronald's paper in 1948, he said that the protecting problem remained difficult because of (*a*) the mixture and proportion of the pigment vehicle, solvent and drier; (*b*) the degree of cleanliness, type of surface, temperature and dryness of surface to be painted; (*c*) the method of application; (*d*) the effect of light radiation and atmosphere; (*e*) the thickness of paint films; (*f*) the rate of transfer of heat by radiation; (*g*) the thermal conductivity; (*h*) the co-efficient of expansion in relation to foundation, and (*i*) dielectric value, *etc.*

Returning to Mr. Rayner's paper, primarily emphasizing

inspection, and realizing the complex nature of this protection problem, what chance had the inspector against these odds?

No wonder that progress was not spectacular; it was a long, hard road, and the attitude of many people who were quite satisfied if a yard labourer were appointed as a temporary inspector for the season, was such that they generally got what they deserved.

He had read Mr. Rayner's paper with a very critical eye and would like to say that he co-ordinated his thoughts and applied them to the problem very well indeed.

He sincerely hoped that many painting contractors would study the paper and, knowing some of their many difficulties (e.g., labour, plant, weather conditions and the fact that they were in business to make money) that they would approach the problem with integrity and endeavour with those in the industry to combat this extremely difficult and costly problem.

"Development and Growth of Industrial Gas with Particular Reference to Factory Estates", by H. Capper, M.I.Gas E., A.M.Inst.F., M.I.S.I., L.IM., Divisional Industrial Engineer, South Eastern Gas Board. Delivered in London on 11th November, 1960.

The paper deals only with industrial activities, and examines in general terms the market available to industrial gas in the South East.

The industrial gas load in the South Eastern Gas Board's Area made little progress during 1959-60. A similar trend is also shown in the North Thames Gas Board's returns.

In the South Eastern Area of the country, due to the geographical position of the various oil refineries, the industry is meeting strong competition from petroleum products.

It is prudent, therefore, to examine the present industrial market available to the industry, and, with the help of market surveys, examine the trade uses of gas in the various categories of consumers and the effect of the major users upon supporting industries. This information should enable the industrial gas engineer to direct attention and skill to expanding those sections of the market that are, at the present time, for various reasons reducing their requirements.

The movement of industry within the London boundaries to organized council factory estates, does not enable the Board to hold the load lost in London, whereas the private and statutory built factory estates, where the interest is the selling or letting of space only to all types of industries, does allow the Board to obtain a reasonable return for manpower and money invested.

A survey of a large number of productive estates shows that even with a gas supply in every factory, an average of four factories out of 30 use 75 per cent of the total estate load.

Building an industrial gas load can take many forms. Some loads are required for production purposes, whilst others are used to destroy the unwanted residue of a process. The 100 per cent gas load obtained from the paint industry at Mitcham, Surrey, was the result of some 25 years of uphill work, technical skill and new developments, and the position the Board now holds is constantly being attacked by its competitors.

With the present tendency for major industries to centralize, in order to achieve maximum efficiency, it is noteworthy that some of the "personal service" trades are now de-centralizing in an endeavour to increase or hold their business, thereby enabling the gas industry to recover a lost steam boiler load.

The future demand for industrial gas is far from promising. The price of gas has increased in greater proportion than that of its main competitors, which are prepared to give long-term contracts and will aggregate consumptions to give lower prices.

There are also large quantities of liquefied petroleum gases available at low prices and relatively sulphur-free.

The rising gas price must be halted by lower production costs. Technical service to the consumer must be increased and the confidence of the manufacturers of fuel-burning appliances must be won back. Plans for campaigns and other methods are in hand in an endeavour to hold and increase the industrial load.

Discussion

Mr. A. E. TYRRELL (London) said that the facts presented by Mr. Capper were of the greatest interest. He, too, considered the small increase in industrial gas load in both London Boards disappointing; the North Thames Gas Board's total sales for the year were up by 5 per cent, but he wondered if this could continue with regard to the national situation. Higher increases in other areas, particularly the Midlands, could be related to industries with high export progress.

Conditions in London were related to national policy of dispersing industry to new and selected areas; but for this, for example, Fords' extension would have been at Dagenham instead of Merseyside.

There was also the problem of keeping pace with intricate mechanical problems as well as thermal problems of automation. The problem of recruitment, training and keeping after training of the right type of young men is being tackled by a new sandwich course in industrial Gas Engineering followed by attractive conditions designed to meet competition from other industries.

A start on a market research investigation had been commenced by the North Thames Board and it was hoped that this could be developed on a national basis. The bearing or part bearing of the cost of a main to a new factory of good potential was always considered.

The concentration of so much of the load in so few factories, notably those using heat treatment, was undesirable, and efforts to spread load to smaller industries were made.

The possibility of holding business by offering long-term contracts at a fixed price of gas were under consideration.

Mr. W. J. JOHNSON (South Eastern Gas Board) agreed on the value of collected information and that it would be better done at a national level. He did not consider the author pessimistic, but rather as having sounded a note of warning. He felt that a more skilled approach to selling was needed.

Mr. R. E. JOHNSTON (Croydon) spoke in support of Mr. Johnson and the possibility of a new version of "1,001 Uses for Gas". Industrial gas sales staff were inadequate numerically to collect the information; it must be done by the laboratories.

The jet tube burner strengthened the industry's position by giving the advantages of a muffle in any furnace in which it was employed. He agreed that long-term agreements would be necessary to combat oil and liquefied petroleum gas. Advertising of gas for industry should be employed.

Mr. J. V. RIGG (London) referred to no emphasis being put on the large commercial catering load in factory canteens; from figures quoted in the paper, it would appear that this was a large and valuable adjunct to the industrial load. In fact, if all the 5,000 factories in the author's area quoted as not using gas did use gas for catering at the quoted figure of 3,000 therms/year, a potential load of 15 mill. therms existed. The author's views would be appreciated on this.

The AUTHOR, in reply, thanked Mr. Tyrrell for opening the discussion and said that, despite the 5 per cent increase in gas consumption for this year and the comparison that could be drawn from relating industrial gas sales to the index of industrial production, he was not satisfied with the sale of gas in the South East.

In using a basic figure of 3,000 therms per factory on a new factory estate, in all but one estate the estimated total annual load had been exceeded. He agreed with Mr. Tyrrell that the possible load to be obtained from a factory estate must be based upon similar types of estate and information that could, and must, be obtained locally if the economies were to be accepted by the Board.

They were, at present, making a cold canvass of a large number of small factories in an endeavour to increase the industrial load, if only by the installation of small gas-burning appliances.

Although he agreed that the large users should receive some reward, the analysis of the medium groups showed that these

groups paid an average higher price than the average price paid per therm by the domestic large user.

He had, in his paper, said that he was neither an optimist nor a pessimist, but for want of another word, called himself an "equanimatist", which he interpreted as meaning "not easily elevated or depressed" and he had indeed planned a canvass of the factories to prove that his conclusion was only a cloud that might pass in due course.

Mr. Johnson did, some years ago, agree to his supplying a hard-backed container into which the "1,001 Uses for Gas" could easily be clipped. This the author found extremely useful when discussing the use of gas with a possible consumer, and even to this day he found that some of these booklets were still being used in the factories. He would, therefore, ask The Gas Council and the Industrial Gas Development Committee to supply authoritative information in book or leaflet form, which could be supplied to the factory personnel.

The contribution made by Mr. R. E. Johnston confirmed the statement outlined in the paper.

The author submitted that the right persons to collate factual information should be the laboratory personnel.

The figure of 3,000 therms mentioned by Mr. J. V. Rigg referred to a particular central canteen used by a number of Decca factories. However, the factory canteen load is a most important part of the industrial load and it is correct to say that if every factory had its own canteen, they could increase their load considerably and they were giving this section of their load special attention with good progress being made.

He had always found that they did get considerable help from Mr. Emmerson in selling appliances using gas as the fuel. This is no doubt due to his close connexion with those in the industry.

Mr. Capper and Mr. Johnston had both said that appliance manufacturers no longer supported the Gas Board as they had done in the past, although gas-fired appliances were still technically equal to, or better than, appliances working on oil.

Mr. Tyrrell had said that the price differential between the fuels was not all-important. Why was it, therefore, that manufacturers, as it was alleged, preferred to sell oil-fired appliances? Surely the answer was partly in the Board's hands.

The manufacturer was concerned basically with selling his appliance; the choice of fuel did not directly concern him. The Boards could help themselves in two ways, (i) by having greater liaison with manufacturers, and (ii) by ensuring that their representatives, with their unsurpassed opportunities for close contact with consumers got to know of their requirements before manufacturers found out for themselves.

Personal Notes

Appointments

(*a*) The Minister of Power has made the following appointments;—

WEST MIDLANDS GAS BOARD

Chairman: C. H. Leach, M.A., as from 31st July, 1961.

SOUTHERN GAS BOARD

Chairman: A. F. Hetherington, D.S.C., B.A., as from 31st July, 1961.

(*b*) The Gas Council has made the following appointments:—

GAS COUNCIL LONDON RESEARCH STATION

Director: G. U. Hopton, B.A., B.Sc.

(*c*) The following appointments of members of the Institution have been made by the under-mentioned Gas Boards:—

EASTERN GAS BOARD

Ipswich Division—
Divisional Commercial Officer: L. F. H. Stanford.

EAST MIDLANDS GAS BOARD

Notts. and Derby. Division—
Divisional Technical Sales Engineer: J. R. Taylor.

Sheffield Division
Doncaster Works—
Works Engineer: F. J. Painter.

SCOTTISH GAS BOARD

Development Engineer: D. C. Elgin.
Glasgow and Western Division—
Domestic Sales Manager: R. Cowie.

SOUTHERN GAS BOARD

Southampton Works—
Station Engineer: J. C. Hogg.
Assistant Station Engineer: J. R. Fairman.

WALES GAS BOARD

Assistant Distribution Engineer (General): V. Sutherland.

General

Mr. C. J. BULLOCK, B.Sc. (AM) has recently taken up the position of Chief Chemical Engineer with Bennett, Sons and Shears, Limited, Leeds.

Mr. A. B. DAWSON (AM) has now taken up his appointment as Industrial Heating Engineer with the Auckland Gas Company, Limited, New Zealand.

Mr. J. M. DOW (M) took up his new appointment as Engineer and Manager of the Belfast Corporation Gas Department on 1st December, 1960.

Mr. J. E. MILLS, B.Sc. (AM) has recently taken up his appointment as Development Engineer with Williams (Hounslow), Limited.

Mr. P. C. SMITH (AM) was installed as President of the New South Wales Institute of Gas Engineers at the First International Gas Industry Convention held in Sydney, Australia, in October.

Retirements

Mr. C. E. BYRT (M) has retired from his position with Newton Chambers and Company, Limited.

Mr. D. E. CATTLIN (M) has retired from his position as Divisional Industrial Gas Engineer with the Kent County Division of the South Eastern Gas Board.

Mr. L. V. PALMER (AM) has recently retired from his position as Draughtsman with the South Eastern Gas Board.

Mr. C. J. Phillips (AM) has recently retired from his position as Works Superintendent at The Southampton Works of the Southern Gas Board.

Mr. J. R. WATERFIELD (M) has retired from his position as Station Engineer with the North Thames Gas Board.

Addresses Required

The Council would be grateful to receive the present addresses of the following members, last heard of in the places given in brackets:—

Mr. M. G. Barnes, (Harrogate).
Lt.-Col. E. W. Black, R.E., T.D., (Cape Town, South Africa).
Mr. M. T. Boyden, (Oxford).
Mr. F. Bush, (Salisbury, Southern Rhodesia).
Mr. E. Clark, (Bridlington).
Mr. K. F. Keeble, (Grahamstown, South Africa).

Institution Register

Elections

In connexion with the 26th Autumn Research Meeting, the following elections were made by ballot, in accordance with By-Law 29.

***To Membership* (4)**

Caddick, Roy, Chief Engineer, Construction Department, W. J. Jenkins and Company Limited, Retford.

Kirkaldy, John Lillie Ramsay, B.Sc., Ph.D., Senior Lecturer in Chemical and Gas Engineering, College of Advanced Technology, Birmingham.

Shimomura, Akira Thomas, Ph.D., Technical Adviser to Shizuoka, Chubu, Shikoku and Nihonkai Gas Companies, Japan.

Towler, John Hedley, M.Sc., Ph.D., Area Chief Chemist, North Eastern Gas Board.

***To Associate Membership* (47)**

Ambrose, Bruce Alexander, Mechanical Engineer, North Shore Gas Company Limited, Sydney, Australia.

Batten, Ronald Alfred, Technical Assistant, Headquarters Division, North Thames Gas Board.

Bingham, Brian Henry, Gas Engineering Assistant and Acting Shift Control Engineer, East Greenwich Works, South Eastern Gas Board.

Birkett, Iain Malcolm, Technical Assistant, Tyneside Division, Northern Gas Board.

Chandler, Derek Hugh Warwick, Assistant Chemist and Relief Shift Control Engineer, Sydenham Works, South Eastern Gas Board.

Clough, John Hacking, Shift Engineer, Lostock Hall Works, North Western Gas Board.

Craiggs, David, Technical Assistant, Northern Gas Board.

Davies, Harry, Central Control Officer, Area Headquarters, South Eastern Gas Board.

East, Alec Percy Ralph, Industrial Representative, North Thames Gas Board.

Ghaffar, Shoaib Abdul, B.E., Industrial Service Engineer, Karachi Gas Company Limited, Pakistan.

Hammond, Anthony Edwin, Assistant Engineer, Coventry District, Warwickshire Division, West Midlands Gas Board.

Hedges, William Sydney Garth, Industrial Service Engineer, Tottenham Division, Eastern Gas Board.

Hill, Roger Leonard, B.Sc., Chemist, Southern Gas Board.

Hoare, Terence William, Technical Assistant, Smethwick Works, Walsall Division, West Midlands Gas Board.

Hodnette, David Geoffrey, Divisional Draughtsman, Wolverhampton and District Division, West Midlands Gas Board.

Horner, Derek Ralph, Technical Assistant (Industrial), York-Harrogate Group, North Eastern Gas Board.

Hussain, Ahmed, M.Sc., Gas Analyst, Sui Gas Transmission Company Limited, Karachi, Pakistan.

Johnson, Alfred Arthur, Industrial Representative, Kent County Division, South Eastern Gas Board.

Kelly, Robert Lewis, B.Sc., Chemist, Watson House, North Thames Gas Board.

Larcombe, Richard Gerald, Technical Assistant (Manufacture) Taunton District, South Western Gas Board.

Loverseed, David Edwin, Technical Assistant (Distribution), Nottingham District, East Midlands Gas Board.

McCrae, Stuart Rice, B.Sc.(Eng.), Assistant Lecturer in Gas Engineering, Enfield Technical College.

Mackechnie, Alastair Menzies, B.Sc., Technical Sales Representative (Industrial), Glasgow and Western Division, Scottish Gas Board.

Marris, James Hugh Spencer, Technical Assistant, North Western Gas Board.

Mills, Donald, Gas Engineering Assistant, East Greenwich Works, South Eastern Gas Board.

Nance, Michael Fred, B.Sc., Chemist, Southern Gas Board.

Norris, Jeremy David, Technical Assistant, Smethwick Works, Walsall Division, West Midlands Gas Board.

Palmer, Stanley Gordon, Assistant Engineer, North Wales Gas Grid, Wales Gas Board.

Richards, Brian, Technical Assistant, North Western Gas Board.

Richards, Stanley Robert, Laboratory Assistant, Watson House, North Thames Gas Board.

Shallcross, William Charles, Assistant Industrial Gas Engineer, Mersey Group, North Western Gas Board.

Siddiqui, Mohammad Ghouse, M.Sc., Utilization Engineer, Karachi Gas Company Limited, Pakistan.

Simpson, John Owen, Assistant Regional Distribution Engineer, Oxford Region, Southern Gas Board.

Spaull, John Bellamy, Technical Assistant, Birkshall Works, Bradford Group, North Eastern Gas Board.

Stark, Angus McCracken, Technical Assistant (Engineering), Dumbarton Works, Glasgow and Western Division, Scottish Gas Board.

Sutton, Jack Victor, Laboratory Engineer, Watson House, North Thames Gas Board.

Thompson, Francis, Technical Assistant, St. Helens Works, South Lancashire Group, North Western Gas Board.

Tooley, Malcolm Reginald, Technical Assistant, Litchurch Works, Derby District, East Midlands Gas Board.

Vanstone, Frederick Charles, B.Sc., Chemist, Central Laboratories, Southern Gas Board.

Verma, Sushil Kumar, B.Sc., Technical Assistant, Tyneside Division, Northern Gas Board.

Walker, David Lindsay, B.Sc.(Tech.), Engineer, Research and Development Department, R. and J. Dempster Limited, Manchester.

Way, David Douglas, Technical Assistant (Distribution), Bath District, South Western Gas Board.

Whitehouse, Charles Donald, Technical Assistant (Distribution), Northampton District, East Midlands Gas Board.

Williamson, David Michael, Senior Technical Assistant, Aberdeen Works, Scottish Gas Board.

Wolstencroft, Kenneth, Assistant Engineer, Camberley Works, Reading Region, Southern Gas Board.

Woodward, Harold, Technical Assistant, Higginshaw Works, Central Lancashire Group, North Western Gas Board.

Wyle, Joseph Geoffrey, Divisional Draughtsman, Wolverhampton and District Division, West Midlands Gas Board.

***To Associateship* (22)**

Anderton, Joseph, Group Distribution Superintendent, Great Yarmouth Group, Eastern Gas Board.

Berge, Frank Claude, Development Engineer, Gas Division, Structural Services Limited, London.

Birch, Michael Joseph, Senior Assistant Engineer, Portsmouth Works, Southern Gas Board.

Bird, William Eric, District Manager, Border District, Edinburgh and South Eastern Division, Scottish Gas Board.

Brackenbury, Thomas Herbert, Group Distribution Engineer, Wellingborough Group, East Midlands Gas Board.

Charles, Frederick Henry, Chief Chemist, Gas Association of New Zealand Incorporated, New Zealand.

Clifford, Ronald Ernest, Engineering Assistant, Watson House, North Thames Gas Board.

Davies, Peter, B.Sc., Graduate Engineering Trainee, Birmingham Division, West Midlands Gas Board.

Dixon, Paul Duncan, Staff Instructor, North Thames Gas Board.

Graham, John, Assistant Distribution Superintendent, Wolverhampton and District Division, West Midlands Gas Board.

Hayashi, Kiyomi, Chief of Research Section, Shizuoka Gas Company Limited, Japan.

Kirk, Frank, Technical Assistant, Car House Works, East Midlands Gas Board.
Kitson, Avril Margaret, B.Sc., Research Physicist, North Thames Gas Board.
Lloyd, Kenneth John Ambrose, District Manager, Lowestoft District, Norwich Division, Eastern Gas Board.
Lloyd, Robert Guy, Chemist, Northampton Group, East Midlands Gas Board.
Martin, John Harris, Shift Supervisor, Westfield Works, Central Division, Scottish Gas Board.
Nicol, Duncan Rennie, Industrial Representative, North Thames Gas Board.
Potter, Horace, Group Distribution Officer, Clwyd and Deeside Group, Wales Gas Board.
Spencer, Leonard Adams, Senior Technical Assistant, Londonderry Gaslight Company, Northern Ireland.
Stevens, Michael Henry, Assistant Engineer, Colombo Gas and Water Company Limited, Ceylon.
Stone, Clifford Douglas, Gas Examiner, Ministry of Power.
Turner, Arthur Richard, Divisional Commercial Officer, Cambridge Division, Eastern Gas Board.

Transfers

To Membership

Bennett, William John, M.Sc., Reigate.
Crispin, William, Great Harwood.
Laming, Frederick George, Orpington.

To Associate Membership

Broomhead, Harry, Kettering.
Parker, William Duncan, B.Sc., London.

Admissions to Studentship

Barber, Gregory Ronald, Birmingham.
Cleall, Peter Martin, London.
Cook, Edward James, London.
Cosgrove, Anthony Joseph, Nottingham.
Davis, John Edward Henry, London.
Espezel, Anthony Charles, London.
Harrison, John Caldwell, Chorley.
Head, Alan, London.
Jackson, Michael Raymond, Romford.
Mozley, John Ewart, London.
Penney, John Everard, Sunbury-on-Thames.
Wolstenholme, Brian Henri, Southport.
Wood, Kerry Michael, Bushey Heath.

Resignations

The following have resigned their membership of the Institution:—

(*a*) ***As from 31st December, 1957:***

Sheldrake, Thomas Wentworth Swinborne, Guildford.

(*b*) ***As from 31st December, 1959 (In addition to those reported in Bulletin for January, 1960 : p. 22):***

Arnold, William Ernest, London.
Brown, Montague James Johnson, Worcester.
Burch, George Arthur, Aldershot.
Burtonshaw, Leslie Nassau, Dawley.
Cartwright, Horace William, Sutton.
Chambers, James Laurence, Solihull.
Chapman, Herbert Anthony, Coltishall.
Chivers, Reginald Henry, Abingdon.
Clarke, William Henry, Coventry.
Crowther, Reuben, Bury.
Dumbleton, Harry, Dublin.
Emery, William Herbert, Cosham.
Grieve, Thomas Frater, B.Sc., Uddingston.
Hands, Alec Saxby, Pinner.
Jones, Robert, Liverpool.
Kerr, Horace, London.
Metcalf, Charles Ernest, M.B.E., Deal.
Neil, George, Southampton.
Payne, William Ernest, London.
Pemberton, Richard Charles, M.C., B.E., Auckland.
Prater, Thomas Harold, Margate.
Rose, John Alexander, Thorpe Bay.
Scargill, Frank Lane, Derby.
Scott, William, Inverness.
Smithson, Richard Mervyn Noel, Heswall.
Townsend, Clifford Charles, Cambridge.
Wadsworth, Cyril, Chandler's Ford.
Yule, David, Kelso.

(c) ***As from 31st December, 1960:***

Banford, Francis Edward, Birmingham.
Bridgewater, Horace, Dudley.
Budden, Kenneth Charles, Chessington.
Byrt, Charles Edward, Seaton.
Cattlin, Douglas Wellsley, Tonbridge.
Chadderton, Edward, Oldham.
de Comminges, Bertrand, Paris.
Edwards, Sydney Henshaw, Bournemouth.
Evans, Cyril Claude, Bridgend.
Gray, Percy, Bexhill.
Griffith, Roland Hall, Ph.D., B.Sc., London.
Griffith-Jones, Morley Aytoun, O.B.E., Clitheroe.
Grover, Hubert William. London.
Hall, William Henry Burr, B.Sc., Saffron Walden.
Hallett, Peter George, Barnstaple.
Holland, Michael Trevor, Teddington.
Holtam, Arthur George, Cheltenham.
Hopkinson, Percy, Chesterfield.
Howes, Frederick Norman, M.C., Chelmsford.
Ilsley, Arthur Forbes, Barnet.
Kimmins, Lionel George, Ashford.
Langford, Alfred Robins, M.B.E., Plymouth.
Lippett, Leslie George, Hythe.
Marston, Edward Bright, Warrington.
Mills, Frederick John, Verwood.
Mills, Philip John, Canada.
Nash, Edwin Charles, London.
Palmer, Lionel Verney, Brighton.
Redfern, Rowland Thomas, Chesterfield.
Richardson, Cyril Walter Mayne, Sevenoaks.
Sanderson, Sydney Alan, Chorley Wood.
Sapsford, James, B.Sc.(Tech.), Southampton.
Sim, Peter Moncrieff, Manchester.
Soar, Ernest, Nottingham.
Surman, Cyril William, Ballymena.
Suthon, John, Wellington.
Tucker, Horace John Robert, Thorpe Bay.
Wheaton, Sidney Herbert, Brentwood.

Re-Election

To Associate Membership

Murray, Graham Francis James, B.Sc., London.

Deaths

The Council regrets to announce the death of the following members of the Institution:—

(*a*) *Honorary Member*:

Smith, Sir Ernest W., C.B.E., D.Sc. (Effingham) M. 1913, HM. 1957; died 7th November, 1960.

(*b*) *Members :*

Ashworth, John Dawson (Altrincham) M.1950 ; died 18th November, 1960.
Glover, Ronald Brown, M.C. (Wilmslow) M.1934 ; died on 30th November, 1960.

(*c*) *Associate Member*:

Pullan, Henry Walter, M.Sc. (Leeds) AM.1950; died 31st August, 1960.

Meetings of District Sections and Junior Gas Associations

Lectures on Natural Gas in France

Through the initiative and co-operation of the scientific office of the French Embassy in London, and of Gaz de France, arrangements have been made for Monsieur Odier, an English-speaking engineer of Gaz de France, to speak to District Sections about the development of natural gas in France and in the Sahara. Special meetings of the Sections will be held for this purpose on the afternoons of the following days:—

30th January, 1961	Joint Meeting of London and Southern and Eastern Sections. (London.)
31st January, 1961	North of England Section. (Newcastle-upon-Tyne.)
1st February, 1961	Manchester and District Section. (Manchester.)
2nd February, 1961	Wales and Monmouthshire Section. (Cardiff.)
3rd February, 1961	Midland Section. (2.30 p.m. College of Technology, Gosta Green, Birmingham.)

(a) District Sections

The following additional meeting will be held in January, 1961:—

THE INSTITUTION OF GAS ENGINEERS—LONDON AND SOUTHERN SECTION

17th January	Paper, "Gas Characteristics Relative to Utilization", by L. W. Andrew. (2.45 p.m. The Caxton Hall, Caxton Street, London, S.W.1.)

(b) Junior Gas Associations

EASTERN

25th January	Paper, by W. D. Harrison. (Cambridge.)

LONDON AND SOUTHERN

6th January	Short Paper Evening. "Fluid Couplings", by P. A. W. Styles, and "Planning Small Holder Stations to Reduce Operational and Maintenance Costs to a Minimum", by R. G. Langford. (6.30 p.m. Westminster Technical College, Vincent Square, London, S.W.1.)
10th January	Visit to the London Electric Wire Company, Limited, Leytonstone.

MANCHESTER

18th January	Visit to the Works of the National Gas Engine Company, Ashton-under-Lyne. Short Papers for the F. Johnston Prize.

MIDLAND

5th January	Visit to the Pleck Works of the West Midlands Gas Board. (2.30 p.m. Prince Street entrance.) (This visit has been postponed from 15th December, 1960.)
10th January	Paper, "The Quest for Simpler Mechanical Maintenance in Gas Works", by R. L. Tarratt. (Staff Mess Room, West Midlands Gas Board, Council House, Birmingham.)
24th January	Paper, "The Distribution of Gas Through Steel Pipelines", by W. Jones. (Staff Mess Room, West Midlands Gas Board, Council House, Birmingham.)

SCOTTISH (EASTERN)

7th January	Short Paper Day. (Dundee.)

SCOTTISH (WESTERN)

13th January	Address by A. McFadyen. (6.30 p.m. Industrial Section, 9, George Square, Glasgow.)

WALES AND MONMOUTHSHIRE (SOUTH WALES SECTION)

9th January	Joint Meeting with Sales and Service Association, South East Section. Paper, "Management and Administration for Sales Results", by A. Facer. (Newport.)

WALES AND MONMOUTHSHIRE (NORTH WALES SECTION)

11th January	Paper, "Grid Supplies in North Wales", by Mr. Barker. (Point of Ayr.)

WESTERN

18th January	Visit to the works of Stothert and Pitt, Limited, Bath.

YORKSHIRE

14th January	Short Paper Day. "Automatic Operation of Cyclic Gasmaking Plant", by A. Stubbs, and "Trunk Feed to Vertical Retorts", by R. Skilbeck. (Wakefield.)

Meetings of Kindred Bodies

The following meetings of kindred bodies have been arranged for January, 1961. Members of The Institution of Gas Engineers who wish to attend any of the meetings, but are not members of the bodies concerned, should apply to the appropriate Secretary at the address indicated.

THE INSTITUTE OF METALS
(17, Belgrave Square, London, S.W.1.)

19th January	Paper, "The Heat-treatment of Engineering Components", by E. Mitchell. (6.30 p.m. College of Technology, Gosta Green, Birmingham.)

THE INSTITUTION OF CHEMICAL ENGINEERS
(16, Belgrave Square, London, S.W.1.)

10th January	Paper, "Selection of Prime Movers in the Petroleum Chemical Industry", by H. H. Meyer. (6.30 p.m. Chemical Engineering Lecture Theatre, The Manchester College of Science and Technology, Jackson Street, Manchester.)

THE INSTITUTION OF MECHANICAL ENGINEERS
(1, Birdcage Walk, London, S.W.1.)

18th and 19th January	Symposium on Pressure-vessel Research towards Better Design.

THE ROYAL SOCIETY OF ARTS
(John Adam Street, Adelphi, London, W.C.2.)

23rd and 30th January	Cantor Lecture. "The Chemical and Plastics Industries", by J. Taylor, M.B.E. (6 p.m.)

THE PIPELINE INDUSTRIES GUILD
(7, Iddesleigh House, Caxton Street, London, S.W.1.)

10th January	Lecture: "Internal Coating", by J. Rogers. (6.30 p.m. Lancaster Room, Caxton Hall, London, S.W.1.)

THE INSTITUTION OF STRUCTURAL ENGINEERS
(11, Upper Belgrave Street, London, S.W.1.)

24th January	"The Provisions of the Revised British Standard for the Use of Structural Steel in Building—B.S. 449 : 1959", by W. C. Andrews, O.B.E. (7 p.m. The Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow.)
25th January	"The Provisions of the Revised British Standard for the Use of Structural Steel in Building—B.S.449 : 1959", by W. C. Andrews, O.B.E. (6.30 p.m. The Heriot-Watt College, Edinburgh.)

THE COMBUSTION ENGINEERING ASSOCIATION
(70, Jermyn Street, London, S.W.1.)

24th January	Paper, "Heating and Ventilating Problems". (Manchester.)
25th January	Paper, "Open Discussion on Coal, Oil and Gas in Industry". (Birmingham.)

Library Accessions

The following are a few additions to the Library since the issue of *Bulletin* No 72 (November, 1960):—

(*The*) Australian Gas Industry Statistical Year Book, 1959. (National Gas Association of Australia.)

"Temperature Measurement in the Refractoriness-under-Load Test", by The Refractories Testing Committee. *Technical Note* No. 7, 1960.

(*The*) British Coke Research Association, 16th Annual Report 1959.

British Standard 758: Part 2: 1960 ("Specification for Small Domestic Hot Water Supply Boilers Using Solid Fuel", Part 2: "Thermostat-controlled Boilers").

British Standard 1710: 1960 ("Specification for Indentification of Pipelines").

British Standard 3250: Part 1: 1960 ("Thermal Testing of Domestic Solid-fuel-burning Appliances with Convection", Part 1: "Flue Loss Methods").

British Standard 3274: 1960 ("Specification for Tubular Heat Exchangers for General Purposes").

"Fuel Consumption in Schools" (Second Supplement): "Tests with Coal-fired Automatic Stoker Warm-air System". Ministry of Education *Building Bulletin* No. 13, June, 1960.

"Gas Chromatography Abstracts 1959", edited by C. E. H. Knapman and C. G. Scott. Butterworths, 1960. (The Publishers.)

(*The*) Gas Council Industrial Gas Conference, Ashorne Hill, 5th to 8th September, 1960. Papers presented.

"Gas Data Book, 1960." American Gas Association Bureau of Statistics.

"Gas Facts 1960.". American Gas Association Bureau of Statistics.

"Gas Handbook for Architects and Builders". The Gas Council, 1960. (The Publishers.)

"Industrial Gas Handbook". The Gas Council, 1960. (R. F. Hayman, Esq.)

"Installation Code for Gas-burning Appliances and Equipment"—Supplement No. 2. Canadian Standards Association, B149-1958, Supplement No. 2-1960.

International Clean Air Conference Proceedings, 1959. National Society for Clean Air. (Dr. F. J. Eaton.)

"Methane Transportation by Sea", by E. C. B. Corlett and J. F. Leathard. Royal Institution of Naval Architects, 1960.

(*The*) New Zealand Gas Industry Statistical Year Book, 1959. (The National Gas Association of Australia.)

"(*The*) Protection of Gas Plant and Equipment from Corrosion". Papers presented at the Joint Symposium of the Society of Chemical Industry Corrosion Group, the Birmingham College of Technology and The Institution of Gas Engineers, September, 1960.

"Research for Industry 1959". A Report of Work done by Industrial Research Associations in the Government. D.S.I.R., 1960.

"Statistiques Officielles de l'Industrie Gazière en France pour l'Année 1959. Ministère de l'Industrie et du Commerce, Direction du Gaz et de Electricité. (A. Lihrmann.)

U.S. Bureau of Mines:

"Back-pressure Tests on Gas-storage Projects", by C. J. Walker, J. S. Miller and H. N. Dunning. *Report of Investigations* 5606, 1960.

"Equilibrium Pressures of Hydrogen Sulfide and Carbon Dioxide Over Solutions of Potassium Carbonate", by J. S. Tosh, J. H. Field, H. E. Benson and R. B. Anderson. *Report of Investigations* 5622, 1960.

General Notices

Christmas Lectures for Young People

The following additional particulars of the Christmas Lectures under the aegis of the Midland Section of The Institution of Gas Engineers, briefly mentioned in the *Bulletin* of November, 1960, are now available:—

13th January, 1961, at 10.30 a.m.—

Lecture on "Flame", by Mr. J. E. Cooper, B.Sc., in the hall of the Matthew Boulton Technical College, Suffolk Street, Birmingham.

18th January, 1961, at 10.30 a.m.—

The same lecture in the Mackworth Secondary School, Derby.

Industrial Radiology

A course of six lectures on industrial radiology will be given by Mr. J. C. Rockley, M.I.E.I., and Dr. J. W. Warren, M.Sc., on successive Tuesdays commencing 3rd January, 1961, at the Brunel College of Technology, Woodlands Avenue, Acton, W.3. The lectures will be of interest to graduates and holders of Higher National Certificates in engineering and science subjects who require an introduction to the radiological methods of testing, as well as to inspectors and others engaged in this work.

The fee for the course is £1. Enrolment may be effected by personal attendance at the College or by written application for an enrolment form.

Exhibition of Scientific Instruments

The 45th Exhibition of scientific instruments and apparatus, organized by The Institute of Physics and The Physical Society, will be held in the Royal Horticultural Society's Halls, Vincent Square, London, S.W.1, on 16th to 20th January, 1961.

Tickets of admission may be obtained from the Secretary, The Institute of Physics, 47, Belgrave Square, London, S.W.1.

The Institute of Metals

Dr. J. E. Hilliard, of the Research Laboratory, General Electric Company, Schenectady, U.S.A., is to give a lecture on "Metallurgical Research at High Pressures", under the auspices of the Metal Physics Committee of The Institute of Metals. The meeting will take place at the Institute's headquarters, 17, Belgrave Square, London, S.W.1, on Thursday, 12th January, 1961, at 6.30 p.m. Visitors are welcome; tickets are not required.

British Productivity Council

A one-day conference on "Integrated Data Processing", defined as "the development of the most streamlined and automatic flow of data practicable within an organization", will be held at the Connaught Rooms, London, W.C.2, on 16th February, 1961.

Details of the programme and ticket application forms may be obtained from the British Productivity Council (I.D.P. Conference), 21, Tothill Street, London, S.W.1.

In connexion with the above, attention is drawn to a report by a mission of the European Productivity Agency to the United States of America, published by H.M. Stationery Office under the title "Integrated Data Processing and Computers" (price 10*s.* 6*d.*).

Heating and Air Conditioning Exposition

The 15th Heating and Air Conditioning Exposition, organized by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., will be held in Chicago (U.S.A.) on 13th to 16th February, 1961.

Details of the programme may be obtained from the Society at 234, Fifth Avenue, New York, 1, N.Y.

Library

The Library and Reading Room of the Institution are open on weekdays between 9 a.m. and 5.30 p.m. Members may borrow books by post, excepting books of reference and certain others, on application to the Secretary.

Benevolent Fund

Contributions to the Benevolent Fund of the Institution may be paid at any time to the Honorary Secretary of the Benevolent Fund, 17, Grosvenor Crescent, London, S.W.1. It is a convenience if annual contributions are made by banker's order, and it is particularly advantageous to the Fund if such contributions are made by Deed of Covenant, whereby the Fund is able to reclaim from the Inland Revenue an appropriate sum in respect of income tax paid by the contributor. Further particulars, with deed forms and banker's orders for completion, are obtainable from the Honorary Secretary of the Fund.

Officers of District Sections and Affiliated Associations

Sections

Eastern

Chairman:	E. H. Winch, M.I.Gas E., Eastern Gas Board, 52, Sidney Street, Cambridge.
Honorary Secretary and Treasurer:	J. Hunter-Rioch, M.B.E., M.I.Mech.E., M.I.Gas E., Eastern Gas Board, 52, Sidney Street, Cambridge.

London and Southern

Chairman:	J. A. Hepworth, B.Sc., M.I.Gas E., North Thames Gas Board, Monck Street, London, S.W.1.
Honorary Secretary and Treasurer:	J. T. Veryard, B.Sc., M.I.Gas E., South Eastern Gas Board, Katharine Street, Croydon.

Manchester and District

Chairman:	W. Hodkinson, O.B.E., M.I.Gas E., North Western Gas Board, Bridgewater House, 60, Whitworth Street, Manchester.
Honorary Secretary:	J. Castle, B.Sc., M.I.Gas E., North Western Gas Board, Radiant House, Bold Street, Liverpool, 1.
Honorary Treasurer:	A. Harrison, M.I.Gas E., 297, Bramhall Lane South, Bramhall, Cheshire.

Midland

Chairman:	S. K. Hawthorn, M.I.Gas E., West Midlands Gas Board, Saltley Gas Works, Birmingham.
Honorary Secretary:	D. K. Green, M.I.Gas E., Gas Works, Foleshill Road, Coventry.
Honorary Treasurer:	J. H. Wainwright, M.I.Gas E., Gas Offices, Powke Lane, Blackheath, Birmingham.

North of England

Chairman:	B. Richardson, M.I.Gas E., Northern Gas Board, Central Laboratory, Redheugh Gas Works, Gateshead.
Honorary Secretary:	J. R. Matthew, M.I.Gas E., Gas Offices, Thomas Street, Consett, Co. Durham.
Honorary Treasurer:	W. Cummings, Assoc.M.I.Gas E., Northern Gas Board, 30, Grainger Street, Newcastle-upon-Tyne.

South Western

Chairman:	T. W. Jackson, M.I.Gas E., South Western Gas Board, 9a, Quiet Street, Bath.
Honorary Secretary:	F. C. Gay, M.B.E., F.C.I.S., Assoc.I.Gas E., Radiant House, G.P.O. Box No. 141, Bristol, 1.
Honorary Treasurer:	T. A. Nicholson, Assoc.M.I.Gas E., South Western Gas Board, 34, Bridge Street, Taunton.

Wales and Monmouthshire

Chairman:	S. L. Wright, B.Sc., M.I.Gas E., Wales Gas Board, Grangetown Gas Works, Cardiff.
Honorary Secretary:	J. Powdrill, M.B.E., Assoc.M.I.Gas E., Wales Gas Board, Bute Terrace, Cardiff.
Honorary Treasurer:	O. P. Cronshaw, M.B.E., M.I.Gas E., Wales Gas Board, 93, Wellington Road, Rhyl, N. Wales.

Affiliated Associations

Irish Gas Association

President:	J. W. Kneeshaw, Clonmel Corporation Gas Department, Clonmel, Co. Tipperary.
Director:	N. J. Robertson, A.I.Gas E., Alliance and Dublin Consumers' Gas Company, Dublin, Eire.
Acting Honorary Secretary and Treasurer:	Miss D. Colthurst, 24a, D'Olier Street, Dublin, Eire.

Scottish Association of Gas Managers

President:	D. Beavis, M.I.Gas E., Scottish Gas Board, 1, Rothesay Terrace, Edinburgh.
Honorary Secretary and Treasurer:	W. Kirk, M.I.Gas E., Kessington, 29, Union Street, Greenock.

British Junior Gas Associations' Joint Council

Chairman:	J. D. Grant, M.A., A.M.I.Gas E., North Thames Gas Board, 109, Nine Elms Lane, London, S.W.8.
Honorary Secretary:	L. G. Townsend, M.Sc., M.I.Gas E., North Western Gas Board, Hind Street, Birkenhead, Cheshire.